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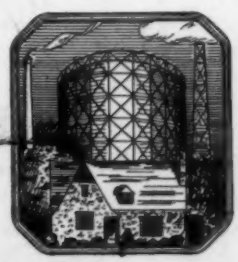

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Editorials

NOT so long ago many of us were of the opinion that the chief concern of the gas industry had to do with the matter of load building; we felt rather certain that problems and procedure in gas making and gas distribution were fairly well set—at least for the present and immediate future. However, a glance at the program of the Conference of the Production and Chemical Committees, to be held the twenty-second and twenty-third of the current month, will open our eyes to the fact that things in this connection are in the saddle, so to speak. Incidentally, the research work done in the recent past along the line of developing manufacturing standby equipment and processes, to be thrown into the breach in the event of interruption in the supply of natural gas, has contributed not a little to this gas manufacturing renaissance. For this latter urge imparted by the natural gas side of our industry, dyed-in-the-wool manufactured gas men should be duly grateful.

Back of all this renewed manufacturing interest lies the desire to produce gas at lower cost and to guarantee continuity of service to our customers. Obviously, these are contributory factors of no small moment to renewed sales efforts.

We can hopefully anticipate the development of new and the perfecting of old gas making processes by reason of this activity. And, it can be suggested at this juncture, attendance at the above-mentioned Conference will assuredly assist all who are concerned with production problems.

WE quote the following from Mr. N. Henry Gellert's address before the recent meeting of the Southern Gas Association:

"The method of regulation which limits the earning capacity of public utilities when people as a whole are prosperous, when consumers can afford to pay high prices for all commodities and also for public service, when the extra profit that might be earned by the utilities does not interfere with the economic progress of its customers,—is contributory to the unhappy situation in which many utilities and their consumers find themselves today.

"It would be far better to formulate a program which would enable public utilities to retain, within reasonable bounds, earnings in excess of so-called 'fair returns,' which excess earnings might be impounded or controlled by commission regulation, so that they might act as a reserve to be given back to the consumers in the form of rate reductions in times of unusual economic distress.

"The rendering of public service would then be paid for in accordance with a price curve following the lines of other commodities,—going up when other prices go up, and down when other prices go down. Certainly this would meet with the approval of public utility officials and executives who see the need of reduced rates, and are powerless to institute them."

Think over these remarks, Mr. Public Service Commissions and Mr. General Public, and—in view of the energetic competition we are getting from oil, electricity and other heating media—if you do not agree that the gas industry no longer has a monopoly and therefore is entitled to more sensible and more flexible regulation, we miss our guess.

MANY of our unsuccesful efforts to solve bedeviling problems are due to two main causes: first, regarding the problem as a very complicated, mysterious critter, and second, losing sight of the fact that the selfsame problems' solution lies in the proper application of well known fundamental laws and principles. And this applies equally in the case of both making and marketing a product or service.

We can well recall one of our first classes in calculus and the admonition from the professor to the effect that if one knew his algebra, geometry and the other fundamentals well and possessed even a slight acquaintance with mental gymnastics, he would have no more fear of a graceful sign of integration that he would of a well-cooked beef steak.

Next month the colleges will turn out another crop of raw-material for business and industry; some of these men will find their way into gas companies. Their superiors should encourage them to study and re-study the fundamental laws of the behavior of gas and fuels and it would not be amiss for these superiors to acquaint themselves with these truths from time to time. Thereby "front" and bluff—those short cuts to success which flourished so luxuriantly up to 1930—will give way to brains and we'll all be a *thundering* lot better off.

AS various facts and data are brought to light, it becomes apparent that the work done by Mr. Frey and his committee in gathering the proper statistics for use in furthering gas range sales is of a very high order; indeed, it is difficult to see how we have managed to make as much headway in the sales of cooking by gas as we have, without the help of the information which this committee has unearthed.

Even so, this data will only be of value if it is backed by energetic selling on the part of salesmen, whether of the gas companies or the dealers. If the information, curves, maps, etc. are to be considered the entire answer to our problem of re-selling gas cooking to the housewife, then the committee might well deem itself affronted and give vent to sulphurous expletives. No first-rate selling job was ever done solely with prettily drawn graphs.

Henry M. Riley

Editor.

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NEW *Air-Cooled* ELECTROLUX THE *Gas* REFRIGERATOR

Notes on High Pressure Gas Distribution

DISTRIBUTION ENGINEER *Outlines Method of Inspection, Repair and Testing of Governors*

THE efficacy of field repairing has been discussed in other sections, so that it will be assumed in this section on shop repairing that the accepted policy is to return all governors removed to a shop, since it is by far the most common practice. Not only the governors removed because of operating difficulties, but also those taken out for such reasons as discarding of services, tearing down of houses and replacement with larger sizes should be brought into the shop, as they offer an excellent opportunity for examination and test.

Tagging Faulty Governors

When governors are removed because of repeated difficulties, such as frequent blowing without any apparent cause, or for particular reasons, as continued vibration, leaks impossible to rectify, difficulty with the mercury seal, etc., a card should be attached stating the reason. These governors should be minutely examined in the shop before they are disassembled to determine the exact causes, and the easiest methods of rectifying them. It is sometimes possible from these observations to report corrective methods to the complaint of repairmen, thus eliminating the necessity for removing a governor. If any particular trouble is found frequently, the manufacturer should be advised so that the design itself may be changed.

For the purpose of repairing, a bench should be provided as convenient for the work as possible without being elaborate or excluding its use for other purposes. It will be noted in figure 1 that the repair section is situated between two windows and the upper section of the room is light colored which increases the illumination of the room, while that section which may come in contact with tools, parts or hands is of a dark color to preserve appearances. The top of the bench is covered with heavy galvanized sheet iron and for each repairman there is a piece of steel plate two feet by two feet square by 3/8" thick which in the photograph is immediately under the tools. All governors are disassembled and assembled on this steel plate, which is easily cleaned and not dented by continual use. Few tools are needed, the most common being a special socket wrench for removing orifices, a fixed end wrench for flange and door plate bolts, a screw driver, pliers and an ordinary one-half pound ball-pein hammer. In certain makes of governors special pliers assist in removing valves and cotter pins.

Nearby are small bins of galvanized sheet iron to hold such parts as mercury cups; inlet, outlet and vent plugs; assorted bolts and nuts; mercury containers and other parts, depending on the type of governor to be repaired.

Handling Mercury

The proper quantity of mercury for use in each governor in the repair shop and the field is put up in a small bottle capable of holding five ounces. The weighing and bottling of the mercury in the storeroom has been found to be economical, as it avoids under or over-filling the cups, losses from spilling or breakage of a container holding large quanties, and makes for ease of carrying from truck to governor location, thereby obviating loss of installer's or repairer's time.

Obviating Spilling

The soap suds are kept in a shallow can of large diameter and the shellac bottle is set into a metal container with a large square base, so that they can not be easily overturned. A rack is provided with a drip pan underneath on which diaphragms are hung when disassembling and assembling governors and oiling diaphragms. The pan is made movable to provide added room when work other than governor repairs is in progress.

Not shown in figure 1 but conveniently near in the shop, is a drill press of a standard type equipped for holding the orifice socket wrench against the orifice with considerable force and stiffness for the purpose of removing particularly tight orifices, this being accomplished by turning the body of the governor.

Toward the back of the bench are air connections to which hoses may be connected for cleaning parts by blowing. While these air connections are used more often on work other than governor repairs, it will be found advantageous to have the

Layout of Governor Repair Bench

tool used for scraping out of the parts after boiling connected with a supply of air directed to clean continuously the edge of the tool and blow the loosened material clear of the part being scraped. The force of the blow may be easily controlled to prevent scattering the loose material around the shop.

Only Room for Proper Tools

It will be noted that there is only one drawer convenient to the governor repair section of the bench, as it is felt only sufficient drawer space to contain a single supply of tools should be provided since excess room makes for an accumulation of defective tools and parts which will handicap the repairman, waste time and may result in poor workmanship. Once a tool or part becomes defective, it should be immediately given to the tool repair department or discarded.

In the repair work it is often necessary to wipe off parts; for this, rags are preferable to waste, as the latter readily adheres to parts and may become lodged in a moving part where it would later cause trouble.

A tool often found useful in the repair work is a so called "easy-out" which may of necessity have to be used on a removable orifice should the usual means become defective. It grips a part by being driven into the inside, such as the orifice tube, where hardened sharp edges dig into the sides and turning is facilitated by a large square shank. Caution should be taken to drive the "easy-out" into a brass orifice only sufficiently to grip, or the added driving will wedge the orifice still tighter.

First Step in Repairing

The first step in actual repairing is the disassembling of all parts so that each individual item may be thoroughly cleaned and examined. The door plate, removable cover and, on some designs, the mercury cup gaskets should be thoroughly scraped off the flanges, if not before, at least after boiling. Due to corrosion, the flange bolts are sometimes difficult to unscrew, in which case economy dictates breaking them with a chisel which is easily accomplished without breaking any cast parts, as they usually of soft steel.

The diaphragm plates should be taken off of the diaphragm so that all parts of the leather may be inspected; this inspection consists in holding the diaphragm up to a strong light to detect pin holes, observing worn parts so that sharp corners or defective parts of weight plates or flanges may be corrected, and noting the general appearance for determining whether it is suitable for re-use. All of these observations should be made while disassembling each unit, so that the cause of any observed trouble may be rectified before the various parts are placed in the stock piles. Diaphragms having any gum on the interior or exterior should be discarded, as the treatment for removal would weaken the diaphragm while those suitable for future service should be treated by oiling, drained by hanging and stored, each of which operations should receive the same careful attention and treatment as given to meter diaphragms.

Care of Valve Discs

Valve discs which have been in service should never be re-installed, even though their appearance is excellent, as the replacement cost is small compared to the total cost of a complaint. Care of the discs from the time they are stamped out until they are placed in the governor, either in the repair shop or in the field, is important. Whether the discs are received separately or attached to a cup or holder, they should be wrapped in such a manner as to exclude the possibility of foreign matter adhering to their surface. The usual manner of accomplishing this is to place two of the discs face to face and wrap them in paper. In the repair shop, when only one disc is used, there is usually a clean space where the other may be placed until required, but in the field, the one not used should be immediately wrapped and kept from all damaging contacts. It takes only a little scratch—even one not readily noticeable—to preclude lock up.

Lever arms should be removed wherever possible to facilitate cleaning of the lever arm chamber. In one type of lever arm governors and in several designs of the toggle type, it is impossible to remove the lever arm, but in these cases the lever arm chamber is usually wide enough to allow for convenient cleaning. In the toggle types, where the arms can not be removed, the disc holder should be, since gummy substances in the guides are common sources of trouble.

The removable orifice is taken out to facilitate examination which should always be accomplished with the aid of a reading glass to detect the least scratch or defect across its seat, either of which irregularities warrants discarding, as they will be the cause of slow build up and weeping, if not actual blowing.

Regrinding Orifices Impractical

Orifices cast with bottom section necessitate removing the lever arm for proper observation and where the lever arm can not be removed, a removable orifice should be insisted upon. Re-grinding of an orifice of either removable or integral types has been found impractical. The regrinding of cast iron too often results in added flaws being exposed, chipping of the casting and removing a quantity of material which would change the distance from valve hinge center to the seat of the orifice, thereby changing the flow and lock-up characteristics. The latter reason also applies to a removable orifice and, in addition, the cost of replacement averages less than the cost of re-grinding in the repair shop.

The diaphragm set screw is removed to prevent foreign matter accumulating between it and the top casting.

The dip tube, even when held in place by screw threads, is not removed, as extra precautions are taken in the factory assembly to make the joint between it and the casting permanently tight to prevent leakage of gas from the gas chamber into the vent. There would be no particular advantage to removing the dip tube, but it should be carefully cleaned out after the boiling operation.

Handling Old Governor Parts

In some old types of governors it is necessary to keep all parts together, as each governor is individually machined and assembled and it will be found an economy to discard this type. In the modern designs all parts are interchangeable and, therefore, it is possible to place each part in a stock by itself usually underneath the bench until sufficient have been accumulated to warrant the starting of boiling and rinsing operations.

In the lower left hand corner of figure 1 is shown a common type of

boiling kettle which can approximately accommodate the parts from ten governors. This size is more than sufficient to accommodate a single repairman. A solution the same as has been found desirable for removing the gum from meters, such as a strong caustic solution, is used, with the advantage that the boiling of governor points can continue for a much longer period than meter parts, which facilitates cleaning. This kettle is heated by gas burners underneath. It will be found an advantage to keep the kettle boiling violently to secure the advantages of a scrubbing action from the resulting circulation. There is a hood about four feet above the boiling kettle and rinsing tank to carry off the fumes which are irritating. The gums found in house governors are much more resistant to the methods of removal than are those found in meters, so that it is advantageous to have separate boiling kettles for governors.

Use of Rinsing Kettle

Near the boiling kettle is a rinsing tank into which the parts are placed while still hot from the boiling operation and rinsed with hot water applied with as much force as surrounding conditions will allow, since the force of the water materially assists in removing the gummy substances still adhering to the parts. A top on the rinsing kettle and properly designed sprays fed by high water pressure materially speed the washing with more effective results. It is not always possible to remove all of the gummy substance in the rinse but, by stocking the parts and allowing them to thoroughly dry, the caked substances are easily removed by scraping or brushing. The scraping process should thoroughly remove all remaining substances, as otherwise they may interfere with the operation of the governor or meter, since they are light in weight and easily carried by the gas stream.

In reassembling, the lever arm should be replaced so as to eliminate movement in any direction except that required to open and close the valve. Except for the disc, governor parts are not subject to much wear, so that the cause of a lever arm with excess play or angularity can usually be traced to a displaced or defective fulcrum hinge. Where lever arms are not removable, the above troubles would warrant discarding that section of the governor.

In replacing the orifice very little joint compound should be used on the threads or the flange, as in most designs, especially those where installation is through the inlet, an accumulation of the compound on the flange would not allow the orifice to be screwed into its proper position, and lack of a tight flange joint may result in leakage across the orifice. Where an orifice is installed through the outlet, excessive compound would be left inside of the gas chamber where it may adhere to the disc and be the source of trouble. It is practically impossible to make a satisfactory test for leakage on this joint but with proper care on installing, no trouble need be expected, but this possibility should be kept in mind should the lock-up test result in a slow build up after using several new discs.

In a utility having several makes of governors it is sometimes possible to interchange diaphragms. This practice should not be allowed because of the possibility of partially or completely stopping up the breather tube, the difficulty of securing the proper amount of excess diaphragm between plates and flanges, wrinkling of the leather between the flanges and the diaphragm plates being installed off-center. Further, after long service in one style of governor, the diaphragm naturally becomes shaped or blocked, thereby adding stiffness to any but the type in which it was initially used, and, if flexed in any but the original places, it would be physically weak along the line of the original maximum flexure. If new diaphragms are used, they should be punched at the factory or in a die as an added precaution against stoppage of the breather hole and to give the proper excess between plates and flanges. The holes for flange bolts should always be punched in place of notching which latter would allow the diaphragm to be pulled into the governor. It is good practice to use shellac or a similar material on both flanges, between which the diaphragm acts as a gasket, to assure gas tightness, as an additional safeguard against the diaphragm being pulled out in the spacing between flange bolts and to assist in preventing drip oil leakage.

Where Not to Use Shellac

On the other gaskets shellac or its equivalent should not be used, as it is frequently necessary to take these joints apart in the field and this would add to the fieldman's work, since the gasket would be torn apart in the removal and require scraping before replacement. A grease compound is sometimes used on these gaskets, but it has the disadvantage that foreign particles readily adhere and may make it difficult to secure a tight joint, whereas a plain gasket should be all that is necessary if the flange is evenly compressed. In the type of governor having the valve arm attached to the door plate, the door plate gasket should be of the thickness specified by the governor

manufacturer to prevent the disc being off-center from the orifice. On toggle types, where the throat casting is separate from the body, the same precaution applies, but the reason is so as not to change the valve travel. Where gaskets are necessary on the mercury seal a slight difference in thickness is of little importance, since the blowing pressure would only be altered by an insignificant amount. Door plate and mercury seal gaskets are usually interchangeable. Various types of packing rubber and other materials have been tried as gasket material but the most common type is sheet packing. Gaskets, when necessary on the plugs at the end of the lever arm hinge, must be of the proper thickness to prevent jamming the hinge or, in some governors, allowing any play.

Testing Repaired Governor

The test of a governor which has been repaired does not differ from that which would be made at a factory after assembling new parts. The object of the test is to determine that the governor meets certain standards of service expected by the consumer and also to eliminate as far as possible operating difficulties, the most common of which are no gas complaints, the governor blowing and leaks. Since no gas is a condition resulting from excessive amounts of gum, it is not possible to make any test of that condition. Some manufacturers and utilities feel that service depends on the characteristics when gas is being passed and, therefore, a real criterion is a test with the governor passing gas. Standardization of governors has made the flow characteristics uniform and possible to predict from the lock-up pressure.

Since the chief operating difficulty is a governor blowing, the important point to test for is the lock-up pressure after the disc has been forced against the orifice by natural operation a sufficient number of times to provide a seat which will produce the same lock-up pressure on successive trials. Since lock-up pressure is an indication of both service and operating conditions, it offers the simplest method for testing a governor.

An elaborate apparatus to test for lock-up pressure is neither necessary nor desirable in the average repair shop, as the quantity of governors repaired per man is small. In a manufacturing establishment increased production in a few cases may warrant the cost of an apparatus which will clamp a governor in place and provide a mercury seal in one quick operation.

A simple bench arrangement is shown in figure 1 where the high pressure feed is brought up through the repair bench and a plate welded to it, then firmly attached to the bench to prevent turning the pipe when screwing on a governor. A shut-off, preferably of the lubricated plug type cock, is used in preference to other types to guard against bypassing at such times as gas is on the high pressure side and the outlet is not plugged or a governor on for test. The length of the nipple before and after the shut-off depends on the height desired by the repairman. Most repairmen prefer to have the governor on the bench, so that it may be turned in any direction when assembling, rather than screwed on to the test block, in which case the length of the two nipples is not a factor in production due to placing the governor at an inconvenient height for the workman. The threads on both sides of the inlet cock should be made up tightly with litharge and glycerine to prevent their turning when placing or taking off the governor.

Two Shut-Offs Necessary

Some companies prefer to connect the inlet to both air and gas feed lines, as tests for tightness and flow are preferably made with gas, while air is satisfactory for lock-up tests. The connection between air and gas should have at least two shut offs, between which a vent should be run to the atmosphere and kept open when not using the gas, as a precaution of any air backing into the gas lines. In figure 1, a pressure gauge will be noted on the wall for indicating the pressure on the inlet of the governor, which pressure is controlled by a pounds to pounds regulator so as to provide any pressure desired up to the maximum available, not only for governor test purposes but for other repair work.

The outlet of the governor is connected to an apparatus constructed of standard fittings and, as shown in figure 1, one section ends in a hose cock to which the test gauge—in this case a U-gauge—is attached by means of a hose connection. On one leg of the U-gauge is a rider which may be set at the pressure indicated immediately after closing the outlet cock, so that should there be any build up of the lock up pressure, the position of the water column above the rider will serve as an indication without the necessity of noting down readings or continuously observing the gauge. The other leg of the apparatus consists of a shut off cock followed by fittings which lead the air or gas away from the repairman to protect him from injury due to any particles carried by the air or gas. When gas is used for all tests, it is well to have a hose connection attached by means of slip couplings to the end of this leg to conduct the gases out of the room.

Outlet Joints Not Made Up Tight

The outlet joints need not necessarily be made up as tightly as the inlet threads, since they are not put under as much strain when assembling or disassembling the test apparatus; but, it is desirable to make them sufficiently tight to guard against any possible leakage.

The procedure for the test is as follows: place the governor and apparatus in position; fill the mercury cup; install a new disc; place the outlet cock in an open position to prevent sudden closing of the valve and to blow out foreign matter; turn on the inlet cock; close and open the outlet cock at least five times for the purpose of establishing a natural seat on the disc—at the same time observing the pressure indicated by the U-gauge at each lock-up, to see that it is approximately at normal and also observing the outlet pressure during the flow as a rough check on the operation of the governor; shut the outlet cock, leaving it in that position for the lock-up test. The rider on the U-gauge is set at the pressure indicated immediately after closing the outlet valve.

The flange between the top and bottom castings, the mercury seal, threads or gasket, door plate gasket, gasket between throat and main body, outlet connection and any other possible point of leakage should then be tested with soap suds. It is also desirable to test the U-gauge hose connection where it is attached to the hose cock. This should be

(Continued on page 35)

Domestic Air-Conditioning Unit Should Include ADEQUATE FILTER

This utility's experience indicates owner's satisfaction from vacuum cleaned purified air is important to installing dealer

By H. B. YOST

Combustion Engineer, Hope Natural Gas Company, Clarksburg, W. Va.

OUR experience on installation of air-conditioning systems in Clarksburg would indicate that the home owner has keen appreciation of a system which provides for proper filtering of air. In my opinion, manufacturers' literature and trade journals generally, have not sufficiently stressed the importance to health of pure air. Clean fuel in our heating plant does not satisfactorily take care of the situation.

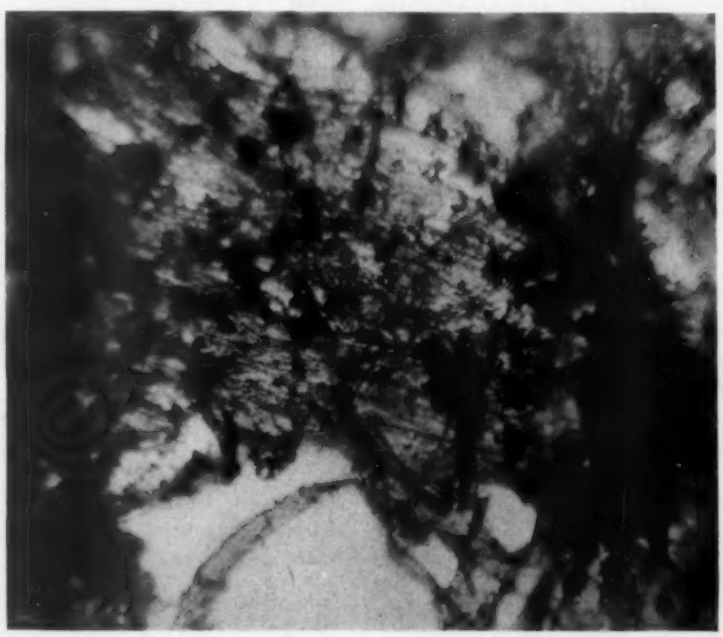
We are constantly subjected to the contamination of our atmosphere from our neighbor's plant who uses solid fuel. This consists of soot and ashes which our neighbor's chimney and the smoke stacks of industry are "raining" on our buildings. During October and November, 28.56 tons per sq. mi. fell in this neighborhood. It has been pointed out that literally tons of dirt in the form of soot and ashes are suspended in the atmosphere over every city of the country, to a greater degree where the industrial plants are fired by solid fuel.

Suburbs Not Immune

However, even in remote suburbs at a considerable distance from congested residence and industrial areas we find here, too, the fine particles of such combustion refuse are carried through the air to enter our homes through the smallest cracks and crevices. Geography points out that dust from volcanic eruptions has been carried in the air for hundreds of miles. Valuable draperies, as upholstery, carpets, all kinds of furniture in our home are soiled by this very fine dust. Each dust particle is also a vehicle for bacteria against which our doctors and hospitals wage continuous war.

Municipalities have tried by ordinances to control this menace but constant vigilance on their part has failed to give us full protection. It appears that the only practical remedy against this invasion of dust and soot and bacteria, is to clean and purify the air before we circulate it. Fluid fuel will alleviate the condition to a certain extent by eliminating the dirt and dust in our own basement. However, the only complete way to solve the situation is to adopt an air-conditioning system that embodies a filter that will remove at least 95% of the foreign matter in the air.

There is one other angle on the problem of filtering air that has also not been discussed exhaustively, and that is, the factor of "returned" air circulation. Naturally, the filter will function only to the degree to which the air in the upper rooms is returned through the filter and the unit. In mild weather when the demand for warmer air is low the ordinary system does not recirculate the air frequently enough to give the



Micro photograph of soiled filter from Hot-Kold installation from September 20, 1931, to November 18, 1931, as forwarded for analysis to Mellon Institute. Note the filth embedded in the pores of the filtering medium. Note the open spaces between the fiber where still more dirt may be collected. It is obvious how the filter functions like the hairs in our nostrils to keep dust and bacteria riders from our lungs.

filters an opportunity to function 100%. It is true such filters will remove a percentage of the dust brought to them but not enough air is returned under such conditions. As a consequence, the filtered air in moderate weather with such units is a relatively small part of the total air of the building. A system therefore, to be completely satisfactory in this respect should circulate the air continuously, regardless of the temperature outside. With the air being continuously returned and recleaned, and repurified, naturally a greater degree of comfort will be maintained.

This matter came to our attention through our customers whose homes were so air-conditioned. They were so enthusiastic about the degree of comfort and cleanliness resultant from their installations that we investigated. We took a typical case: Removed the filter from the Hot-Kold air-conditioning system which we had installed, sent it to the Mellon Institute at Pittsburgh, explaining in this instance the fans of the Hot-Kold system had operated continuously for a period of 59 days. We asked them therefore, to analyze the dirt which had been removed from the air during this period as it appeared on the filter. The result of this test by Mellon Institute contains some surprising facts.

Production and Utilization of High Heating Value Diesel Oil Gas

Los Angeles Gas and Electric Corporation investigates value and characteristics of this gas as a standby

ONE of the ten shells in the No. 3 Generating Plant of the Los Angeles Gas and Electric Corporation's Gas Works was chosen for this test. This shell is a single shot, up-blast and down-make machine, 27 feet in diameter and 43 feet in height, containing 62,000 checker brick. The normal rated capacity on 550 B.t.u. oil gas is 4 million cu. ft. per day.

The plan of operation was to make runs on successive days, using varying quantities of steam on each test for make oil injection, with the thought in mind of studying its effect on the quality and quantity of gas produced. A test was also conducted, using natural gas for spraying the make oil, instead of steam.

After each day's run, appliance tests were run on a representative group of appliances as found in the field. The operation of the various appliances, when burning 100% oil gas and various mixtures of oil and natural gas, was observed. The appliances were tested at five pressures and at five mixtures.

Diesel oil was used for make oil, of which a brief analysis is shown below.

Gravity deg. A.P.I. @ 60° F...	33.4
Flash ° F. Cleveland Open Cup	195
Fire ° F. Cleveland Open Cup	225
Water by distillation.....	Trace
B.S.&W. by centrifuge.....	Trace
B.t.u. per lb.	19,700
B.t.u. per gal.	140,819
Viscosity Saybolt Univ. @	
68° F.	51
100° F.	42
210° F.	32
Conradson carbon residue, % by wt.	0.08
Sulphur, % by weight.....	0.60
Ash	0.007
Distillation, ° F. initial	422
10%	470
50%	549
90%	649
Maximum	750
Recovery, % by volume at	
410° F.	0
482° F.	16.5
572° F.	63.0
662° F.	91.0
723° F.	94.3

Fuel oil, of the following brief analysis, was used for heating purposes.

Gravity deg. A.P.I. @ 60° F...	17.1
B.S.&W. centrifuge	0.9
Flash open cup, ° F.....	193
Sulphur bomb test, per cent...	1.22

Both the fuel oil and diesel oil were run through separate heaters and supplied to the generator around 200° F.

Recording meters were installed to measure the make oil, fuel oil, blast air, wash box water, scrubber water, scrubber oil, and steam consumption.

Recording thermometers were also installed to record the temperatures of the make oil, fuel oil, gas after wash box, and scrubbers.

An attempt was made to thoroughly study the temperature conditions inside of the generator and also on the gas off-take to the wash box during the gas making operations. It is believed that the results obtained will clearly show that generator temperatures and even off-take temperatures are of little value in the operation of an oil gas generator.

Considerable time was spent in the installation of the pyrometers and it is felt that temperatures actually recorded were very accurate, as every precaution was taken to test the thermocouples and recorders against standard instruments before the test was started.

Three couples were installed in the shell checker work; one at a point in the checkers 2 feet above the arches, one in the center of the 21 feet of checker work, and one 2 feet down from the top of the checker work. The couples actually extended inside

Portion of report read before Spring Conference, Technical Section, Pacific Coast Gas Assn., Los Angeles, Mar. 2-3, 1933.

of the lining into the checker body for about 10 inches.

The equipment used in these three locations consists essentially of an alloy protection tube entirely enclosed within a carborundum tube. The space between the carborundum tube and the alloy tube is kept under a pressure of air sufficient to overcome the pressure produced by the gas made in the shell, the purpose being to keep the protecting tube and couple in an oxidizing atmosphere and thereby lengthening its life and likewise aid in keeping the couples in calibration. The air also aids in keeping carbon from entering into the pores of the carborundum tube and causing it to crack. As nearly as could be determined, the temperature readings were accurate, since the amount of cool air introduced in the annular space at any time was so slight as to affect the temperature very little, if any. [A detailed sketch of this complete installation may be found in an article entitled "The Influence of Various Types of Checker Brick and Other Factors on Capacity and Operation of Generators," by H. J. Knollman in the 1926 Proceedings of the Pacific Coast Gas Association.]

A couple and alloy protecting tube was placed in the gas off-take within two feet of the outer shell and the last couple and alloy casing was placed in the off-take within 6 feet of the inlet to the wash box.

A Thomas recording calorimeter was installed next to the operating platform of the generator under test. Sample lines were installed to the outlet of the wash box and after the last scrubber. A continuous record of the heating value was obtained on all tests.

The chemical laboratory conducted daily tests on the naphthalene content of the gas, hydrogen sulphide content, chemical gas analysis and tar tests.

Compression tests were likewise run on the gas to determine the quantity of condensate produced when compressing to 60 lbs. and cooling to 60 °F.

Tank gaugings were used to determine the exact quantity of make oil and fuel oil used, the oil meters on the generators being used for operating indicators only. The gas was measured through a Thomas meter and likewise holder corrections were made each day for the quantity of gas in the relief holder.

Operation of Generator on Diesel Oil

The results of six sucessive days' runs will be found in Table No. 1. The average run per day was about 9 hours. The quantity of injection steam was raised from day to day and chemical analyses made in order to detect any difference in the chemical constituents of the various gases produced, if any.

The average heating value produced varied on these tests from a low of 849 to a high of 1,000 B.t.u. The average B.t.u. for the overall test showed 905.

The rate per hour of gas made varied from 173 M. to 231 M. with an over-all average of 200 M. per hour, which is at the rate of 4,600 M.c.f. per day figured on a 23-hour basis.

The gallons of make oil showed a fluctuation from 8.90 to 11.44 gallons per M., which was due to a wide fluctuation in the B.t.u. of the gas produced. The average was 10.23 gallons per M. for a 905 B.t.u. gas.

The fuel figures showed a variation from 0.47 to 0.88 gallons per M., the average being 0.68 gallons per M.c.f. gas made. It is felt that these figures are somewhat low for continuous operation, as standby heat was not figured in the test data. Actual operating figures would more nearly approach 0.8 gallons per M.

The operating cycle was changed from the former 10-20 on 550 B.t.u. oil gas to an 8-12 cycle. The shorter cycle is possible since the Diesel oil has a tendency to vaporize more readily than fuel oil. A more uniform B.t.u. gas is likewise produced by this procedure.

Injector steam was the steam actually used to atomize the Diesel oil through the oil sprays. This quantity was varied from a minimum of 324 lbs. per run to a maximum of 778 lbs. per run in order to study the effect of steam on the gas reaction in the generator. While the injection is taking place, 9 minutes, no other steam enters the shell. After the injection period, the oil is shut off and purged out of the oil loop and injectors by means of a steam purge. This operation is continued for 3 minutes. The steam purge is accomplished through a separate three-inch loop which introduces a large quantity of steam into the shell for a short period of time, the purpose of this being to merely purge out the gas left in the shell after each make period. This operation requires 1½ minutes. The injector by-pass steam is the quantity of steam required to keep the injectors cool while not actually injecting oil. The

Table 1—Generator Operating Data

Date—Feb.	20	21	22	23	24	25	Total
Average B.t.u.	922	1,000	916	925	900	849	905
Gas made, m.c.f.	1,481	1,791	1,459	1,381	1,354	4,088	11,554
Make per hr., m.c.f.	185	173	208	180	193	231	200
Gallons make oil used	16,447	20,493	12,981	14,970	13,536	39,732	118,159
Gallons make oil per hr.	2,056	1,984	1,854	1,954	1,934	2,250	2,049
Make oil, gals. per M.	11.10	11.44	8.90	10.84	10.00	9.72	10.23
Cu. ft. gas per gal. make oil	90.0	87.4	112.4	92.3	100.0	102.9	97.8
Gallons fuel oil used	740	1,573	907	909	638	3,094	7,861
Gallons fuel oil per hr.	92	152	225	119	91	175	136
Fuel oil, gals. per M.	0.50	0.88	0.62	0.66	0.47	0.76	0.68
Total gals. oil per M.	11.60	12.32	9.52	11.50	10.47	10.48	10.91
B.t.u. gas made per gal. make oil	82,980	87,000	102,958	85,378	90,000	87,362	88,509
B.t.u. per gallon make oil	140,819	140,819	140,819	140,819	140,819	140,819	140,819
Thermal efficiency	58.93	61.78	73.11	60.63	63.91	62.04	62.85
M. cu. ft. blast air per heat	217	206	226	145	154	234	199
Heat period, minutes	8	8	8	8	8	8	8
Make period, minutes	12	12	12	12	12	12	12
Lbs. steam usage per run,							
Injector steam	471	491	778	324	[1] 7.3	778	585
Oil loop purge	72	72	72	72	72	72	72
Steam purge	352	352	352	352	352	352	352
Injector by-pass	83	78	83	83	83	83	83
Burner steam	65	65	65	65	65	65	65
Lbs. steam usage per M.							
Injector steam	7.6	8.5	11.2	5.4	[2] 111	9.4	8.8
Oil loop purge	1.2	1.2	1.0	1.2	1.1	1.0	1.1
Steam purge	5.7	6.1	5.0	5.9	5.5	4.6	5.3
Injector by-pass	1.3	1.3	1.2	1.4	1.3	1.1	1.2
Burner steam	1.1	1.1	1.0	1.1	1.0	0.8	1.0
Total steam per M.	16.9	18.2	19.4	15.0	8.9	16.9	17.4

[1] *Natural gas rate 7.3 m.c.f. per run.*

[2] *Natural gas rate 111 cu. ft. per M.*

burner steam is the quantity of steam used by the fuel oil burners during the entire cycle.

Test No. 5 was run without the use of injector steam. In its place, natural gas of 1,122 B.t.u. was used at an injection pressure of 50 lbs.

Chemical Analysis of Diesel Oil Gas

A number of representative analyses were made of the gas produced at various B.t.u.'s and with varying rates of injection of steam and natural gas.

The results all show a very constant quantity of carbon dioxide.

The illuminants, including benzine, vary directly with the B.t.u. and for a 950 B.t.u. gas are approximately 17 per cent.

The oxygen content is very uniform on all the tests and is not excessive.

The hydrogen content, as the illuminants, varies considerably, but the variations seem to be due almost entirely to the actual B.t.u. of the gas and not due to the action of varying quantities of steam. The results seem to indicate that injection with 30 pounds steam pressure is sufficient to complete any steam gas reaction and any further steam merely acts as a cooling agent. Even when natural gas was used for spraying instead of steam, the hydrogen and carbon monoxide content was very comparable with that obtained with steam injection for approximately the same B.t.u.

The carbon monoxide content showed some fluctuation, but for the main part may be considered to be fairly uniform with no particular trend under varying B.t.u. contents or steam injection rates.

The ethane content, which was not reported in any analyses reported by either the San Rafael tests or the San Diego tests, showed a tendency to increase with an increase in B.t.u. values.

The methane content does not seem to show a definite trend, the methane showing about the same for the lowest as for the highest B.t.u. gas tested. The sample using natural gas for injection was somewhat higher in methane, but this merely made up for the methane formed from the natural gas added.

The nitrogen content, for the main part, was fairly uniform and although somewhat high, nevertheless was within the experimental error.

Table 2—Chemical Gas Analysis

Date—Feb., 1933..	25th	25th	24th	22nd	23rd	21st	25th	21st
Time	4:15 P.M.	7:00 A.M.	12:25 P.M.	12:00 Noon	12:20 P.M.	3:40 P.M.	10:10 A.M.	10:15 A.M.
Injected with	90 lbs. Steam	50 lbs. Steam	50 lbs. N.G.	90 lbs. Steam	30 lbs. Steam	50 lbs. Steam	50 lbs. Steam	90 lbs. Steam
Lbs. steam per run	778	471	...	778	324	471	471	778
B.t.u. (obs.)	875	900	940	950	960	970	1020	1080
Gravity (obs.) ...	.570	.580	.625	.660	.662	.690	.675	.745
Carbon dioxide ..	1.4	1.4	1.8	2.3	1.8	1.8	1.7	1.8
Illuminants	13.9	14.5	15.8	16.7	19.3	19.6	20.3	24.2
Oxygen	0.4	0.1	0.2	0.2	0.2	0.3	0.2	0.2
Hydrogen	34.0	30.5	28.8	29.8	30.9	29.9	28.7	23.0
Carbon monoxide.	4.3	2.6	3.9	4.3	3.7	6.2	3.6	2.8
Ethane	1.7	1.5	3.9	3.7	4.0	2.8	3.8	3.8
Methane	37.9	44.0	42.4	37.5	34.4	38.1	36.6	37.8
Nitrogen	6.4	5.4	3.2	5.5	5.7	1.3	5.1	6.4

Generator Temperatures

As previously outlined, temperatures at five locations in the generator were recorded; one in the off-take near the shell or lower off-take, one in the off-take near the wash box inlet or upper off-take, then the three temperatures in the bottom, middle and upper checker body.

Table No. 3 gives a summary of the maximum and minimum average temperatures at these various locations for the six operating days with a record of the average B.t.u. produced.

A close analysis of these figures seems to indicate that the only locations that show a definite trend are the upper and low off-takes. Of these, the lower off-take seems to respond quicker to the action of changes in the generator operations. Even the lower off-take can be greatly influenced by rate of gas produced, conditions of fire box and lower checkers.

Table 3—Generator Temperatures

Date—February	20	21	22	23	24	25
Average B.t.u.	922	1000	916	925	900	849
Lower off-take avg., min.....	....	1131	1278	1253	1272	1315
Lower off-take avg., max.....	....	1313	1471	1415	1416	1544
Upper off-take avg., min.....	973	994	1183	1157	1174	1243
Upper off-take avg., max.....	1218	1169	1375	1275	1308	1326
Bottom checkers avg., min.....	1511	1568	1782	1737	1815	1746
Bottom checkers avg., max.....	1574	1610	1844	1797	1860	1810
Middle checkers avg., min.....	1491	1582	1788	1764	1483	1311
Middle checkers avg., max.....	1542	1597	1820	1802	1559	1387
Top checkers avg., min.....	1361	1583	1648	1636	1012	1047
Top checkers avg., max.....	1464	1669	1740	1687	1114	1146

The temperature of the bottom, middle and upper checkers do not seem to show any definite trend at all as far as the temperature throughout the machine is concerned, and likewise do not follow the B.t.u. of the gas. These results seem to definitely indicate that the temperature throughout the checker body is subject to wide variations in temperatures, even though the shell may be under good operating control.

Table No. 4 shows a typical operating day taken from Test No. 2. This gives the generator temperatures and corresponding B.t.u. by run periods.

Purification Operations

The operation of the Diesel oil gas through the purification system was identical to that of oil gas with the exception of the by-products recovered.

When operating at 950 B.t.u. on Diesel oil gas, no carbon was recovered in the wash box. A tar resembling coal tar was collected in the bottom of the wash box, which was readily drained off. Some tar floated off through the seal pot into the wash box water. The remainder of the tar was caught in the first two water scrubbers. The last two water scrubbers caught only a trace of tar.

Roughly speaking, about 75% of the tar was caught in the wash box, 15% in the overflow water from the wash box and the remaining 10% in the water scrubbers.

The tar coming over in the overflow water had a tendency to float and even upon standing did not seem to settle out. This made it quite difficult to secure an accurate measure of the actual tar content produced. A number of samples were taken and tested for water content. The over-all tar produced figures 2.1 gal-

Table 4—Generator Temperatures

Time Test No. 2	Lower Off-Take Min.	Lower Off-Take Max.	Upper Off-Take Min.	Upper Off-Take Max.	Top Checkers Min.	Top Checkers Max.	Middle Checkers Min.	Middle Checkers Max.	Bottom Checkers Min.	Bottom Checkers Max.	B.t.u.
A.M.											
5:38	....	....	860	1250	1460	1480	1460	1460	1320	1320	830
5:50	....	....	920	1360	1520	1560	1480	1500	1375	1385	855
6:10	....	....	1030	1360	1570	1650	1510	1520	1430	1450	835
6:30	....	....	1130	1220	1620	1720	1520	1530	1440	1450	855
6:50	....	....	1040	1130	1650	1780	1530	1540	1400	1440	865
7:10	....	....	960	1070	1660	1840	1530	1540	1390	1410	875
7:30	....	....	940	1100	1660	1760	1520	1540	1380	1400	880
7:50	....	....	950	1110	1630	1760	1500	1520	1370	1380	930
8:10	....	....	970	1160	1620	1720	1480	1520	1370	1380	980
8:30	....	....	990	1160	1600	1710	1460	1490	1370	1390	1030
8:50	....	....	1020	1180	1580	1670	1460	1480	1380	1390	1040
9:10	....	....	1020	1180	1560	1640	1470	1480	1420	1440	1030
9:30	....	....	1020	1180	1560	1580	1470	1480	1480	1520	1045
9:50	1150	1450	1010	1180	1520	1570	1470	1480	1520	1540	1070
10:10	1125	1425	1040	1170	1480	1550	1470	1490	1560	1600	1105
10:30	1125	1475	1040	1200	1460	1520	1480	1480	1590	1620	1080
10:50	1150	1475	1040	1190	1440	1480	1500	1500	1620	1630	1102
11:10	1175	1535	1050	1260	1420	1460	1500	1520	1660	1670	1105
11:30	1200	1430	1050	1250	1410	1440	1560	1570	1670	1720	1100
11:50	1275	1325	1050	1160	1420	1500	1620	1630	1800	1820	1102
P.M.											
12:10	1175	1240	1000	1090	1420	1490	1620	1630	1820	1880	1090
12:30	1100	1175	1000	1100	1540	1730	1670	1680	1820	1920	1080
12:50	1075	1175	980	1100	1580	1650	1690	1700	1830	1920	1075
1:10	1000	1100	940	1030	1600	1700	1720	1730	1840	1930	1065
1:30	960	1060	920	1010	1700	1850	1740	1750	1760	1900	990
1:50	1025	1125	910	1060	1720	1840	1760	1780	1720	1830	965
2:10	1050	1150	920	1080	1720	1820	1760	1790	1680	1780	975
2:30	1090	1175	940	1130	1760	1880	1770	1800	1650	1730	982
2:50	1150	1400	980	1200	1740	1820	1780	1800	1630	1680	965
3:10	1250	1450	1030	1260	1730	1790	1760	1790	1640	1660	950
3:30	1225	1475	1050	1320	1720	1780	1770	1780	1680	1740	945
Avg.	1131	1313	994	1169	1583	1669	1582	1597	1568	1610	1000

lons per M.c.f. gas made, on a 950 B.t.u. gas.

Table No. 5 gives a complete record of the gas temperatures, and water and oil consumption throughout the purification system.

The hydrogen sulphide content of the crude gas showed an average of 122 grains, which is considerably lower than 550 B.t.u. oil gas.

The naphthalene content is also considerably lower and was readily reduced to below 2 grains with only one oil scrubber.

Total sulphur content after oxide purification showed an average of only 3.7 grains and the hydrogen sulphide content showed only a trace.

In this connection, it might be interesting to show the loss in B.t.u. due to compression of the Diesel oil gas is 50 B.t.u. per cubic foot.

A small air compressor was connected up so as to pump Diesel oil gas against a 60-lb. head and the subsequent gas was cooled to 60° F. The results of two tests conducted on a 950 B.t.u. gas showed condensation of 0.124 and 0.178 gallons of liquid per M.c.f. gas.

Appliance Tests

In testing the operation of a variety of domestic appliances when burning 100% oil gas and various mixtures of oil and natural gas, the appliances were adjusted for natural gas and the adjustments were left the same throughout the experiment.

The two kinds of gases were metered through separate 30 Lt. meters, and the mixtures controlled by means of two 2-inch gate valves. The mixed gases were metered through another 30 Lt. meter into the two-inch appliance manifold. The pressures were controlled by three 2-inch Reynolds dead weight low pressure regulators with a 15" Miriam "U" gauge at the outlet of each meter. The specific gravity and B.t.u. content of each mixture of gas were recorded by means of a Ranarex Recorder and a Thomas Calorimeter.

The appliances were tested at five pressures and at five mixtures. The pressures used were 3½, 5, 7, 9, and 10½ inches water column and the mixtures 100% natural, 75½ natural and 25% oil, 50% natural and 50% oil, 25% natural and 75% oil, and 100% oil gas.

The tests were made on various kinds of oil gases, ranging from 805 to 1,080 B.t.u. with specific gravities averaging from 0.58 to 0.72.

The procedure was to first test the appliances on 100% oil gas at all pressures, thereafter increasing the percentage of natural gas, and observing the appliance operation and flame characteristics at the aforementioned mixtures and pressures. Due to difficulties encountered in maintaining uniform mixtures at low capacities, all appliances were operated simultaneously. The total capacities of the appliances were measured at the various mixtures and pressures and the B.t.u. input of each appliance was determined by the percentage of the total capacity it consumed on natural gas. For example, a furnace represented 9.8% of the total consumption of natural gas at 7 inches pressure and it therefore represents 9.8% of all capacities throughout the tests. These percentages were previously determined by timing each appliance separately and checking

Table 5—Purification Operating Data

Date—Feb.	20	21	22	23	24	25	Average
Temp. After Wash Box, Deg. F..	120	132	146	136	132	150	136
Wash Box Water, Gals. Per M..	81	67	47	54	50	42	57
Temp. Wash Box Water, Deg. F.	73	75	76	76	76	79	76
Temp. Before Scrubbers, Deg. F.	99	113	131	120	116	144	121
Scrubber Water, Gals. Per M...	85	92	73	89	81	69	82
Temp. Scrubber Water, Deg. F...	73	75	75	76	73	74	74
Temp. After Oil Scrubber, Deg. F.	70	64	63	62	61	71	65
Scrubber Oil, Gals. per M.....	13.0	13.4	11.5	13.3	12.4	10.4	12.3
Temp. Scrubber Oil, Deg. F.....	64	63	64	63	63	65	63
* *Hydrogen Sulphide*							
Before water scrubbers.....	...	150.3	126.6	134.5	110.8	87.0	121.8
After water scrubbers.....	...	138.5	110.8	154.3	110.8	...	128.6
After oil scrubbers.....	...	142.4	118.7	142.4	122.7	...	131.5
* *Naphthalene*							
Before water scrubbers.....	...	32.7	...	55.6	59.6	...	49.3
After water scrubbers.....	...	1.8	5.4	8.5	12.8	...	7.1
After oil scrubber.....	...	1.3	1.5	2.9	5.8	...	2.9
* Total Sulphur	...	1.7	6.0	2.1	5.0	...	3.7
Tar Produced in Gallons.....	...	...	...	...	...	...	23,860
Tar Produced, Gals. Per M.....	...	...	...	...	...	...	2.1
Tar Produced, Per cent of Make Gas	...	...	...	...	...	...	20.2

* *Grains per 100 Cu. ft.*

burner steam is the quantity of steam used by the fuel oil burners during the entire cycle.

Test No. 5 was run without the use of injector steam. In its place, natural gas of 1,122 B.t.u. was used at an injection pressure of 50 lbs.

Chemical Analysis of Diesel Oil Gas

A number of representative analyses were made of the gas produced at various B.t.u.'s and with varying rates of injection of steam and natural gas.

The results all show a very constant quantity of carbon dioxide.

The illuminants, including benzine, vary directly with the B.t.u. and for a 950 B.t.u. gas are approximately 17 per cent.

The oxygen content is very uniform on all the tests and is not excessive.

The hydrogen content, as the illuminants, varies considerably, but the variations seem to be due almost entirely to the actual B.t.u. of the gas and not due to the action of varying quantities of steam. The results seem to indicate that injection with 30 pounds steam pressure is sufficient to complete any steam gas reaction and any further steam merely acts as a cooling agent. Even when natural gas was used for spraying instead of steam, the hydrogen and carbon monoxide content was very comparable with that obtained with steam injection for approximately the same B.t.u.

The carbon monoxide content showed some fluctuation, but for the main part may be considered to be fairly uniform with no particular trend under varying B.t.u. contents or steam injection rates.

The ethane content, which was not reported in any analyses reported by either the San Rafael tests or the San Diego tests, showed a tendency to increase with an increase in B.t.u. values.

The methane content does not seem to show a definite trend, the methane showing about the same for the lowest as for the highest B.t.u. gas tested. The sample using natural gas for injection was somewhat higher in methane, but this merely made up for the methane formed from the natural gas added.

The nitrogen content, for the main part, was fairly uniform and although somewhat high, nevertheless was within the experimental error.

Table 2—Chemical Gas Analysis

Date—Feb., 1933..	25th	25th	24th	22nd	23rd	21st	25th	21st
Time	4:15 P.M.	7:00 A.M.	12:25 P.M.	12:00 Noon	12:20 P.M.	3:40 P.M.	10:10 A.M.	10:15 A.M.
Injected with	90 lbs. Steam	50 lbs. Steam	50 lbs. N.G.	90 lbs. Steam	30 lbs. Steam	50 lbs. Steam	50 lbs. Steam	90 lbs. Steam
Lbs. steam per run	778	471	...	778	324	471	471	778
B.t.u. (obs.)	875	900	940	950	960	970	1020	1080
Gravity (obs.) ...	.570	.580	.625	.660	.662	.690	.675	.745
Carbon dioxide ..	1.4	1.4	1.8	2.3	1.8	1.8	1.7	1.8
Illuminants	13.9	14.5	15.8	16.7	19.3	19.6	20.3	24.2
Oxygen	0.4	0.1	0.2	0.2	0.2	0.3	0.2	0.2
Hydrogen	34.0	30.5	28.8	29.8	30.9	29.9	28.7	23.0
Carbon monoxide.	4.3	2.6	3.9	4.3	3.7	6.2	3.6	2.8
Ethane	1.7	1.5	3.9	3.7	4.0	2.8	3.8	3.8
Methane	37.9	44.0	42.4	37.5	34.4	38.1	36.6	37.8
Nitrogen	6.4	5.4	3.2	5.5	5.7	1.3	5.1	6.4

Generator Temperatures

As previously outlined, temperatures at five locations in the generator were recorded; one in the off-take near the shell or lower off-take, one in the off-take near the wash box inlet or upper off-take, then the three temperatures in the bottom, middle and upper checker body.

Table No. 3 gives a summary of the maximum and minimum average temperatures at these various locations for the six operating days with a record of the average B.t.u. produced.

A close analysis of these figures seems to indicate that the only locations that show a definite trend are the upper and low off-takes. Of these, the lower off-take seems to respond quicker to the action of changes in the generator operations. Even the lower off-take can be greatly influenced by rate of gas produced, conditions of fire box and lower checkers.

Table 3—Generator Temperatures

Date—February	20	21	22	23	24	25
Average B.t.u.	922	1000	916	925	900	849
Lower off-take avg., min.....	....	1131	1278	1253	1272	1315
Lower off-take avg., max.....	....	1313	1471	1415	1416	1544
Upper off-take avg., min.....	973	994	1183	1157	1174	1243
Upper off-take avg., max.....	1218	1169	1375	1275	1308	1326
Bottom checkers avg., min.....	1511	1568	1782	1737	1815	1746
Bottom checkers avg., max.....	1574	1610	1844	1797	1860	1810
Middle checkers avg., min.....	1491	1582	1788	1764	1483	1311
Middle checkers avg., max.....	1542	1597	1820	1802	1559	1387
Top checkers avg., min.....	1361	1583	1648	1636	1012	1047
Top checkers avg., max.....	1464	1669	1740	1687	1114	1146

The temperature of the bottom, middle and upper checkers do not seem to show any definite trend at all as far as the temperature throughout the machine is concerned, and likewise do not follow the B.t.u. of the gas. These results seem to definitely indicate that the temperature throughout the checker body is subject to wide variations in temperatures, even though the shell may be under good operating control.

Table No. 4 shows a typical operating day taken from Test No. 2. This gives the generator temperatures and corresponding B.t.u. by run periods.

Purification Operations

The operation of the Diesel oil gas through the purification system was identical to that of oil gas with the exception of the by-products recovered.

When operating at 950 B.t.u. on Diesel oil gas, no carbon was recovered in the wash box. A tar resembling coal tar was collected in the bottom of the wash box, which was readily drained off. Some tar floated off through the seal pot into the wash box water. The remainder of the tar was caught in the first two water scrubbers. The last two water scrubbers caught only a trace of tar.

Roughly speaking, about 75% of the tar was caught in the wash box, 15% in the overflow water from the wash box and the remaining 10% in the water scrubbers.

The tar coming over in the overflow water had a tendency to float and even upon standing did not seem to settle out. This made it quite difficult to secure an accurate measure of the actual tar content produced. A number of samples were taken and tested for water content. The over-all tar produced figures 2.1 gal-

Table 4—Generator Temperatures

Time Test No. 2	Lower Off-Take		Upper Off-Take		Top Checkers		Middle Checkers		Bottom Checkers		
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	B.t.u.
A.M.											
5:38	....	....	860	1250	1460	1480	1460	1460	1320	1320	830
5:50	....	....	920	1360	1520	1560	1480	1500	1375	1385	855
6:10	....	....	1030	1360	1570	1650	1510	1520	1430	1450	835
6:30	....	....	1130	1220	1620	1720	1520	1530	1440	1450	855
6:50	....	....	1040	1130	1650	1780	1530	1540	1400	1440	865
7:10	....	....	960	1070	1660	1840	1530	1540	1390	1410	875
7:30	....	....	940	1100	1660	1760	1520	1540	1380	1400	880
7:50	....	....	950	1110	1630	1760	1500	1520	1370	1380	930
8:10	....	....	970	1160	1620	1720	1480	1520	1370	1380	980
8:30	....	....	990	1160	1600	1710	1460	1490	1370	1390	1030
8:50	....	....	1020	1180	1580	1670	1460	1480	1380	1390	1040
9:10	....	....	1020	1180	1560	1640	1470	1480	1420	1440	1030
9:30	....	....	1020	1180	1560	1580	1470	1480	1480	1520	1045
9:50	1150	1450	1010	1180	1520	1570	1470	1480	1520	1540	1070
10:10	1125	1425	1040	1170	1480	1550	1470	1490	1560	1600	1105
10:30	1125	1475	1040	1200	1460	1520	1480	1480	1590	1620	1080
10:50	1150	1475	1040	1190	1440	1480	1500	1500	1620	1630	1102
11:10	1175	1535	1050	1260	1420	1460	1500	1520	1660	1670	1105
11:30	1200	1430	1050	1250	1410	1440	1560	1570	1670	1720	1100
11:50	1275	1325	1050	1160	1420	1500	1620	1630	1800	1820	1102
P.M.											
12:10	1175	1240	1000	1090	1420	1490	1620	1630	1820	1880	1090
12:30	1100	1175	1000	1100	1540	1730	1670	1680	1820	1920	1080
12:50	1075	1175	980	1100	1580	1650	1690	1700	1830	1920	1075
1:10	1000	1100	940	1030	1600	1700	1720	1730	1840	1930	1065
1:30	960	1060	920	1010	1700	1850	1740	1750	1760	1900	990
1:50	1025	1125	910	1060	1720	1840	1760	1780	1720	1830	965
2:10	1050	1150	920	1080	1720	1820	1760	1790	1680	1780	975
2:30	1090	1175	940	1130	1760	1880	1770	1800	1650	1730	982
2:50	1150	1400	980	1200	1740	1820	1780	1800	1630	1680	965
3:10	1250	1450	1030	1260	1730	1790	1760	1790	1640	1660	950
3:30	1225	1475	1050	1320	1720	1780	1770	1780	1680	1740	945
Avg.	1131	1313	994	1169	1583	1669	1582	1597	1568	1610	1000

lons per M.c.f. gas made, on a 950 B.t.u. gas.

Table No. 5 gives a complete record of the gas temperatures, and water and oil consumption throughout the purification system.

The hydrogen sulphide content of the crude gas showed an average of 122 grains, which is considerably lower than 550 B.t.u. oil gas.

The naphthalene content is also considerably lower and was readily reduced to below 2 grains with only one oil scrubber.

Total sulphur content after oxide purification showed an average of only 3.7 grains and the hydrogen sulphide content showed only a trace.

In this connection, it might be interesting to show the loss in B.t.u. due to compression of the Diesel oil gas is 50 B.t.u. per cubic foot.

A small air compressor was connected up so as to pump Diesel oil gas against a 60-lb. head and the subsequent gas was cooled to 60° F. The results of two tests conducted on a 950 B.t.u. gas showed condensation of 0.124 and 0.178 gallons of liquid per M.c.f. gas.

Appliance Tests

In testing the operation of a variety of domestic appliances when burning 100% oil gas and various mixtures of oil and natural gas, the appliances were adjusted for natural gas and the adjustments were left the same throughout the experiment.

The two kinds of gases were metered through separate 30 Lt. meters, and the mixtures controlled by means of two 2-inch gate valves. The mixed gases were metered through another 30 Lt. meter into the two-inch appliance manifold. The pressures were controlled by three 2-inch Reynolds dead weight low pressure regulators with a 15" Miriam "U" gauge at the outlet of each meter. The specific gravity and B.t.u. content of each mixture of gas were recorded by means of a Ranarex Recorder and a Thomas Calorimeter.

The appliances were tested at five pressures and at five mixtures. The pressures used were 3½, 5, 7, 9, and 10½ inches water column and the mixtures 100% natural, 75½ natural and 25% oil, 50% natural and 50% oil, 25% natural and 75% oil, and 100% oil gas.

The tests were made on various kinds of oil gases, ranging from 805 to 1,080 B.t.u. with specific gravities averaging from 0.58 to 0.72.

The procedure was to first test the appliances on 100% oil gas at all pressures, thereafter increasing the percentage of natural gas, and observing the appliance operation and flame characteristics at the aforementioned mixtures and pressures. Due to difficulties encountered in maintaining uniform mixtures at low capacities, all appliances were operated simultaneously. The total capacities of the appliances were measured at the various mixtures and pressures and the B.t.u. input of each appliance was determined by the percentage of the total capacity it consumed on natural gas. For example, a furnace represented 9.8% of the total consumption of natural gas at 7 inches pressure and it therefore represents 9.8% of all capacities throughout the tests. These percentages were previously determined by timing each appliance separately and checking

Table 5—Purification Operating Data

Date—Feb.	20	21	22	23	24	25	Average
Temp. After Wash Box, Deg. F..	120	132	146	136	132	150	136
Wash Box Water, Gals. Per M..	81	67	47	54	50	42	57
Temp. Wash Box Water, Deg. F.	73	75	76	76	76	79	76
Temp. Before Scrubbers, Deg. F.	99	113	131	120	116	144	121
Scrubber Water, Gals. Per M...	85	92	73	89	81	69	82
Temp. Scrubber Water, Deg. F...	73	75	75	76	73	74	74
Temp. After Oil Scrubber, Deg. F.	70	64	63	62	61	71	65
Scrubber Oil, Gals. per M.....	13.0	13.4	11.5	13.3	12.4	10.4	12.3
Temp. Scrubber Oil, Deg. F.....	64	63	64	63	63	65	63
* *Hydrogen Sulphide*							
Before water scrubbers.....	...	150.3	126.6	134.5	110.8	87.0	121.8
After water scrubbers.....	...	138.5	110.8	154.3	110.8	...	128.6
After oil scrubbers.....	...	142.4	118.7	142.4	122.7	...	131.5
* *Naphthalene*							
Before water scrubbers.....	...	32.7	...	55.6	59.6	...	49.3
After water scrubbers.....	...	1.8	5.4	8.5	12.8	...	7.1
After oil scrubber.....	...	1.3	1.5	2.9	5.8	...	2.9
* Total Sulphur	...	1.7	6.0	2.1	5.0	...	3.7
Tar Produced in Gallons.....	...	...	...	...	...	...	23,860
Tar Produced, Gals. Per M.....	...	...	...	...	...	...	2.1
Tar Produced, Per cent of Make Gas	...	...	...	...	...	...	20.2

* *Grains per 100 Cu. ft.*

against the total consumption.

In general, the flame characteristics and appliance operation using 100% oil gas as compared to natural gas are as follows:

A shorter, sharper flame with a greenish inner cone. Yellow tips are most apparent above 1,000 B.t.u. With the exception of the luminous flame heater, and the instantaneous water heater, this condition would not interfere with the satisfactory operation of the appliances.

Below 900 B.t.u. and pressures of 5 inches and lower, the flames are too short and would undoubtedly cause many poor pressure complaints.

Between 900 and 1,000 B.t.u. all appliances operated satisfactorily with the exception of a radiant heater which back-fired into the air mixer at pressures of 7 inches and lower on oil gas of any B.t.u. content. These conditions existed with the air shutter wide open as adjusted for natural gas, and could be corrected by closing the shutter two-thirds. The luminous flame heater invariably smoked at pressures 9 inches and higher.

With mixtures of 75% oil gas and 25% natural gas, all appliances operated satisfactorily with the exception of a radiant heater which backfired at pressures of 7 inches and lower. At mixtures of 50% and greater of natural gas, all appliances operated satisfactorily, and it would be difficult for the consumer to detect any difference in the flame characteristics.

From the foregoing tests it is evident that an oil gas of approximately 950 B.t.u. content is better suited for consumption in natural gas appliances than the other gases tested. We would recommend a mixture of not less than 50% natural gas to avoid any appliance adjustments in the field.

Conclusions

1. A high B.t.u. oil gas of approximately 950 B.t.u. can be readily produced with only a few minor changes in the plant layout.

2. The capacity of the present generators may be increased approximately 20% over 550 B.t.u. oil gas when producing a 950 B.t.u. oil gas made from a 33-gravity Diesel oil.

3. The operation of the generator, as in the manufacture of 550 B.t.u. oil gas, can be best controlled by close observation of the seal pot overflow. It is felt that an operator will soon be able to determine quite closely the B.t.u. of gas produced by the nature of the tar overflowing in the seal pot. The distinction seems to be quite marked for changes in B.t.u. from 900 to 1,100 B.t.u.

4. The use of varying quantities of steam beyond 5 lbs. per M. for injection does not seem to have any noticeable influence on the character of the gas produced.

5. It is entirely feasible to inject the Diesel oil with high pressure natural gas instead of steam, although the resulting benefits obtained are of a doubtful nature.

6. It is necessary to make a minor change in the wash box water pit in order to separate the tar that floats over the seal pot.

7. The tar produced can be readily handled and when dehydrated should make an excellent boiler or generator fuel.

8. The hydrogen sulphide content is considerably lower than with 550 B.t.u. oil gas.

9. Naphthalene can be more readily removed than with 550 B.t.u. oil gas.

10. The use of temperatures in the generator are of a doubtful nature and the use of the lower off-take temperature, provided the shell is not subject to wide fluctuations in operation, is a fair index of what the generator is producing.

11. The operation of a generator on 950 B.t.u. oil gas is somewhat more sensitive and requires somewhat more attention than with 550 B.t.u. oil gas.

12. It is possible to decrease the operating cycle and therefore produce a more uniform B.t.u. gas.

13. An oil gas of approximately 950 B.t.u. content is better suited for consumption in natural gas appliances than any other B.t.u. Diesel oil gas tested. Furthermore, a mixture of not less than 50% of natural gas is recommended in order to avoid any appliance adjustments in the field.

14. The specific gravity of a 950 B.t.u. oil gas, 0.660, is very near to that of a natural gas, and therefore should not cause any distribution or utilization troubles.

The Gas Producer Heat Balance

A detailed Calculation of the distribution of useful and waste heat in the producer

By JOHN W. ROMIG

THE gas producer has certain heat losses, some of which are controllable and some of which are inherent and unavoidable. In order to study the operation of a gas producer it is necessary to consider all of the losses, sort them out and group the controllable and inherent losses.

Heat is brought in by the fuel (chemical heat and sensible heat), the steam blown, the air blown, and, if hot or warm water is fed to cooling devices, some heat above 60° F. may enter the system when compared to a 60° F. temperature base. Heat leaves the producer in the form of chemical heat in the gas, sensible heat in excess steam, sensible heat in the gas, soot and tar in the gas, carbon in the ash, heat in the cooling water, producer gas leakage, heat in the ash, radiation and unaccounted-for losses.

In a heat balance the minor details are not considered, for they are inherent losses and may safely be lumped together. The chief items of interest are given in Table 1.

Table 1

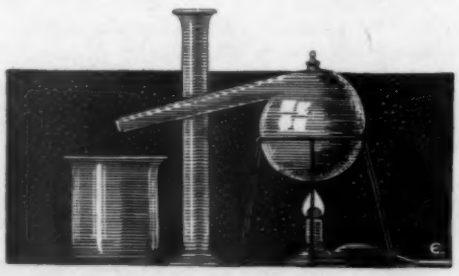
Sources of Heat and Distribution in Gas Producer (Above 60 deg. Fahr.)

Heat Entering Producer
Chemical Heat in Coal
Sensible Heat in Coal
Heat in Steam
Heat in Cooling Water
Heat in Air
Heat Leaving Producer
Chemical Heat in Gas
Sensible Heat in Gas
Heat in Excess Steam
Heat in Combustible in Ash
Heat Lost in Cooling Water
Heat Lost in Soot and Tar Deposit
Unaccounted-for Losses, Radiation, etc.

The heat entering is developed on the basis of B.T.U. per pound of fuel and the balance of useful heat and losses are made on the same unit. Losses in percentages are shown together with B.T.U.s per lb. of coal. A study of the operation of one or more gas producers and tracing the heat distribution give added insight into gas producer operation and, at the same time, offer data upon which to base plans for better gas producer operation.

Comparison of Operations

Many connected with the operation of gas producers compare operation on the basis of gas analysis alone. This method of comparing operations has limitations in that the gas analysis is not tied in with the quantity of fuel. Good gas may be produced from a certain coal, but the number of cubic feet of gas per pound of coal may be low, the result being that much less heat is being delivered than is being suspected. It is the product of the cold gas analysis in B.T.U. and the cubic feet of gas from a pound of coal that really indicates the useful heat derived from the coal. The method of computing the volume of gas from one pound of coal is shown in the heat balance calculations along with the data for computing cold heat units in a cubic foot of gas. Data needed for such comparisons includes the complete gas analysis and the ultimate analysis of the fuel.



While credit is usually given the producer for sensible heat in the producer gas, there may be some question as to the logic followed. In the case of regenerative furnace equipment the producer gas is preheated in the heat exchange. Should the gas be scrubbed the sensible heat is lost along with soot and tar mists carried with the gas. In the case of using hot gas, the producer deserves credit for the sensible heat and for this reason two heat efficiencies are developed. First, the cold gas efficiency represents instances where the sensible heat is lost and second, the hot gas efficiency represents instances where sensible heat is of some value. There is usually a loss in sensible heat in producer gas as it is conducted to a process using hot gas. This loss may be considered as a transmission loss and is found by taking the difference between the sensible heats at the temperature entering and at the temperature leaving the gas main. The transmission loss is not chargeable to the producer but is chargeable to the gas distribution system and is omitted herein.

Table 2

Coal and Gas Data

Coal Analysis (Ultimate) % by Weight as Received		Cold Gas Analysis % by Volume	
Moisture	7.30	CO_2	6.98
Total Carbon	69.40	C_2H_4	0.28
Hydrogen	4.32	O_2	0.41
Nitrogen	1.33	CO	22.50
Oxygen	8.43	CH_4	4.35
Sulfur	0.99	H_2	15.17
Ash	8.23	N_2	50.31
B.t.u. per lb. of coal as received	12,167		

In the followng, a heat balance is developed for an automatically

agitated gas producer fired with No. 2 Southern Illinois (Williamson County) coal. Data for the balance were taken over a period of 1 week and averaged, so that the results are considered as representative of producer and gas conditions. The coal and gas data are shown in Table 2, and general data in Table 3.

Table 3

General Data

Coal per hour (average)	3285 lbs.
Combustible in ash	11.38 per cent
Steam per lb. of coal	0.462 lbs.
Steam Pressure (59 lbs. gauge)	Saturated
Carbon and Tar per cu. ft. of gas at producers	.00022 lbs.
Carbon and Tar leaving collectors per cu. ft. of gas	.00007 lbs.
Water per hour for cooling	600 gallons
Temperature cooling water (inlet)	60 deg. Fahr.
Temperature cooling water (outlet)	90 deg. Fahr.
Temperature of Gas leaving producer	1025 deg. Fahr.
Room temperature air inlet	72 deg. Fahr. dry bulb

The coal and combustible in ash data were secured from laboratory analyses of quartered samples, the producer gas analyses by spot samples analyzed by a modified Orsat and temperatures secured from thermocouples and pyrometers. The quantity of steam per pound of coal was computed from the orifice diameter, steam pressure and rate of fuel consumption. The carbon and tar in the gas was found by pumping a known volume of gas through filters and solvents. Another method of finding this data approximately is to weigh, sample, and analyze the quantity of soot deposited in the gas mains over a period of time, keep the weight of coal gasified over the same period. Care must be exercised to be sure that the data is accurate and representative of conditions or else the results will be misleading.

For the purpose of organizing the computations, the calculations are tabulated and numbered in Table 4.

All units, data and computations are carried out according to the English system and volumes are used in preference to weights in the case of gases. A 60° F. and 30" absolute pressure base is used throughout. The calculations are made in the order shown in Table 4 and include constants and other data that are applicable to the heat balance of any gas producer.

Table 4

Calculations for a gas producer heat balance

1. Cut. ft of cold gas from 1 lb. of coal.
2. Chemical heat in producer gas.
3. Steam decomposed per pound of coal and water vapor accompanying producer gas.
4. Quantity of air entering producer.
5. Sensible heat in producer gas, or heat due to temperature and hot gas heating value.
6. Sensible heat in steam blast above 60 F. per lb. coal and total heat to producer.
7. Heat loss combustible in ash.
8. Heat loss from tar and soot deposited in collectors.
9. Heat loss in cooling water.
10. Heat loss in steam.
11. Summary—heat in, heat out, cold gas and hot gas, efficiencies.

Item No. 1—Cubic Feet of Cold Producer Gas from 1 Pound of Coal—The fundamental of this calculation is the quotient of the carbon content of one pound of fuel entering with the content of one cu. ft. of cold gas. The amount of carbon in one cu. ft. of cold gas is developed in Table A. The carbon from 1 pound of coal is distributed in the form of gaseous products, soot, tar mists and carbon in the ash. By dividing the carbon in the coal by the carbon weight that is found in a cubic foot of gas (corrections made for soot and combustible in ash) the number of cubic feet of gas per pound of fuel are found.

Table A

Carbon Bearing parts of producer T gas	percent by Vol.	Weight carbon lb. per cu. ft. gas constituent
CO_2	6.98	$.0698 \times .0317$
C_2H_4	0.28	$.0028 \times 2 \times .0317$
CO	22.50	$.2250 \times .0317$
CH_4	4.35	$.0435 \times .0317$
Total		.01090 lb. carbon per cu. ft. of producer gas.

The constant (.0317) in the right hand column is the weight of carbon per unit of carbon in a carbon bearing gas.

As the tests for soot and tar in the gas indicated that 0.00022 pound is carried over physically with each cu. ft. of cold gas, the total carbon leaving with one cu. ft. of gas is the sum of the two, or 0.01112 pound. One pound of coal contains 0.6940 pound of carbon. Some of this carbon is lost with the ash, the amount being $.0823 \times .1136 = .0103$ pound

$$\frac{8.23}{1.00 - .1136}$$

per pound of coal, where 8.23 is the per cent of ash in the fuel and .1136 is the carbon in one pound of ash. Subtracting from the total carbon, the net carbon in the gas is .6837 pound. Dividing the carbon in 1 pound of coal by the carbon in 1 cu. ft. of cold gas, we find that 61.5 cu. ft. of gas @ 60° F. and 30" are evolved from 1 pound of coal.

Item No. 2—Chemical Heat in Producer Gas—The net or low-heating value of the gas is shown in Table B.

Table B

Constituent	Percent by Analysis	BTU. per cu ft. pure constituent	BTU. in cold gas per cu. ft.
C_2H_4	.28	1505	4.2
CO	22.50	322	72.5
CH_4	4.35	909	39.5
H_2	15.17	274	41.5
Total of above			157.7
Carbon in gas in gas mains—.0007 × 14600	.00007 pound not deposited in gas mains — .00007		1.02
Total heating value			158.72 BTU. per cu. ft cold gas.

Total heating value 158.72 × 61.5 gives 9760 B.T.U. in cold gas from 1 pound of coal.

Item No. 3—Steam Decomposed per Pound of Coal and Water Accompanying the Gas—The moisture in the coal is driven off at rather low temperatures and appears in the hot producer gas as highly superheated steam. Excess steam blown into the producer is present in the same form. From a hydrogen balance of the producer the steam decomposed and the excess steam are obtained.

H_2 in C_2H_4 equal .0028 x 2 x .00529 —where .00529 is the weight of 1 cu. ft. of H_2 @ 60° F.

H_2 in CH_4 equals 0.435 x 2 x .00529

H_2 in H_2 equals .1517 x 1 x .00529

Total H_2 in 1 cu. ft. of gas is the sum of the above three, which gives a hydrogen total of .00129 pound per cu. ft., and (61.5 x .00129) or

.0783 pound hydrogen in the gas from 1 pound of coal, neglecting humidity of the air blown.

H_2 in the coal as received—from analysis .0432 pound. The weight of H_2 from the steam decomposed is the difference (.0783—.0432) or .0351 pound per pound of coal. As water vapor weighs 9 times the weight of hydrogen, .0351 x 9 equals .3159 pound of steam decomposed per pound of coal.

The water vapor accompanying 1 cubic foot of producer gas is the total of the following:

Moisture in coal:

$$\frac{.0730}{61.5} = .00118$$

pound per cubic foot of gas

Excess steam blown into producers:

$$\frac{.4620 - .3159}{61.5} = \text{pound per cubic foot of gas}$$

Moisture in the air (may be neglected for all practical purposes) in this case is $\frac{.01028 \times 2.966}{61.5} = .00049$ pound per cubic foot of gas

Total of above three items is .00405 pound per cubic foot of gas.

The volume of .00405 pound of water vapor is

.00405 x 21 = .085 cubic foot per cubic foot of gas @ 60 deg. F and 30 inches barometer.

In the calculation of moisture from air blown it is found that 2.966 pounds of air per pound of coal are blown into the producer and there is .01028 pounds of water vapor in 1 pound of air at wet bulb temperature.

From the above it is seen that for 100 ft. of cold gas 8.5 cu. ft. of water vapor accompany the gas.

Item No. 4—Quantity of Air Entering Producer—This calculation is based on a Nitrogen balance of operation.

N_2 in gas for 1 pound of coal = 61.5 × .5031 × .07429 = 2.285 pounds.

N_2 in gas for 1 pound of coal = 0.0133 pounds.

N_2 from air = difference = 2.2717 pounds.

The weight of air per pound of coal $= \frac{2.2717}{.769} = 2.966$ pounds, where 76.9% air is O_2 by weight.

Volume of air per pound of coal = 2.966 × 13.06 = 38.50 cubic feet.

Volume of air blown per pound of steam blown $= \frac{38.50}{.462} = 82.1$ cu. ft. @ 60° F. and 30".

When the amount of coal per unit of time is known, the volume in cu. ft. per minute is readily found. For one test it was found 2285 lbs. of coal were gasified per hour and 2108 cu. ft. of air per minute were required for the producer.

Item No. 5—Sensible Heat in the Producer Gas or Heat due to Temperature and Hot Gas Heating Value—Table C shows the sensible heat above 0° F. for 1 cu. ft. of each constitutent of the producer gas at 60° F. and at 1025° F., which is the producer gas temperature under consideration. The sensible heat of 1 cu. ft. of producer gas and the accompanying .085 cu. ft of water vapor is found for 1025° F. but corrected to a 60° F. base instead of a 0° F. base.

Table C

Gas	Vol. per cu. ft. producer gas	Heat in pure constitutent above 0F. B.T.U. per cu. ft. @ 1025° F.	
CO_2	.0698	31.31	1.47
C_2H_4	.0698	45.18	1.67
CH_4	.0435	51.56	1.46
CO	.2250	19.32	1.14
O_2	.0041	19.32	1.14
H_2	.1517	19.32	1.14
N_2	.5031	19.32	1.14
H_2O	.0850	23.86	1.35

By multiplying the volumes by the corresponding heat contents the total heat in 1 cu. ft. of gas @ 1025° F. is 23.62 BTU. and @ 60° F. is 1.30 BTU. Subtracting, it is found that 22.32 BTU. accompany 1 cu. ft. of gas, or 1733 BTU. in the gas from 1 pound of coal. The total heat in 1 cu. ft. of hot gas is the total:

a. Cold heating value per cu. ft. (chemical) 158.72 BTU.

b. Sensible heat, 22.32 BTU.

Total 181.04 BTU. per cu. ft.

The product of 181.04 and the number of cu. ft. of gas per pound of coal (61.5) gives the hot gas heat value of 11,133 BTU. per pound of coal as the gas leaves the producer.

Item No. 6—Sensible Heat in Steam Blast above 60° F. per pound of Coal. Total Heat to Producer—Heat enters the producer from two principal sources, the fuel and the steam blown. Some heat above 60° F. may enter in the air blown, but this is neglected, as the amount is so small.

It was found that .462 pound of steam, at 59 lbs. gauge, entered with 1 pound of coal. The heat in this amount of steam equals .462 (1183 — 60 + 32) or 535 BTU. per pound of coal, where 1 pound of saturated steam has 1183 BTU. above 32° F. The total heat to the producer is equal to the heat content of the fuel as fired (12,167 BTU.) plus the heat in the steam or 12702 BTU. per pound of fuel.

Item No. 7—Heat Loss Due to Combustible in Ash—As determined in Item 1, .0103 pound of carbon is lost in the ash from 1 pound of coal. One pound of carbon contains 14,600 BTU. and .0103 pound contains 150 BTU. which is the heat loss due to unburned fuel in the ash and clinker.

Item No. 8—Heat Loss from Tar and Soot Deposited in Collectors—Tar and soot in 1 cu. ft. of gas at producer = .00022 pound.

Tar and soot leaving collector = .00007.

Difference is the loss or .00015 per pound cu. ft. of producer gas, which is equal to .00912 pound per pound of coal.

The heat lost considering the total weight of tar and soot as pure carbon is .00912 × 14,600 or 133 B.T.U. per pound of coal. In long gas mains a greater part of the soot and tar is deposited.

Item No. 9—Heat loss in Cooling Water—An average of 600 gallons

of water was raised from 60° F. to 90° F. by the heat absorbed from water jackets, agitator bars, etc. One gallon weighs 8.33 pounds, so the heat loss per hour becomes 600 × 8.33 × (90—60) or 150,000 B.T.U. per hour. With average fuel consumption of 3285 pounds per hour, the loss amounts to $\frac{150{,}000}{3285}$ or 45 B.T.U. per pound of coal.

Item No. 10—Heat loss from Excess Steam—Excess steam carries heat from the producer and, in case of using hot gas for a process, it carries heat from the process. For the balance this process loss is not considered.

Heat in 1 cu. ft. of steam @ 1025° F. is 23.86 B.T.U.; at 60° F. is 1.35 B.T.U. and the heat in .085 cu. ft. above 60° F. is 1.92 B.T.U. per cu. ft. of gas or 118 B.T.U. per pound of coal.

Item No. 11—Summary, Heat In, Heat Out, Cold Gas and Hot Gas Efficiencies—In Table D is tabulated the summary of the heat units entering the producer per pound of coal, the sources and amounts being taken from the foregoing items.

It may be considered by some that the heat balance should be made on a dry fuel basis rather than on the "as received" basis. Fuel is shipped, freight paid and the fuel billed on the "as received" basis and for that reason a balance on any other basis is misleading and not of use for comparison of fuels, producer operation and efficiencies.

The distribution of the heat entering the producer is tabulated in Table E which shows useful heat and losses. The efficiencies are figured from the information assembled in Tables D and E.

The cold gas efficiency is of particular interest when the gas is passed through scrubbers or otherwise cooled before use. The hot gas efficiency shows the efficiency of the producer as a thermal machine and is of interest wherever the gas is used hot. In the case of regenerative or recuperative furnaces the actual value of the sensible heat in the gas may be questioned, as the heat transfer from the waste gases would in some cases be ample for preheating the producer gas. However, in installations where the regenerative or recuperative capacity is limited, the sensible heat is of greater value. Thermally, the producer is more efficient than most thermal machines and processes.

Table D

Source of Heat to Producer	B.T.U. to producer per pound of coal as received above 60° F.	
Heat in coal as received		12,167
Heat in steam blast		535
Heat in water to jackets etc;	neglect	0
Heat in air blown	neglect	0
Total		12,702

Gas producer heat balances have a value in carrying out operations in a producer plant. First, the balance shows where the fuel purchased is going; second, a balance has a value for comparing operation at one time with another or to compare one plant, fuel or style of gas producer with other plants, fuels or producers. A third value is that of educating the foreman and operators relative to conditions in the producer. Losses due to high CO_2 may be shown by running through a balance for a given fuel with a high CO_2 producer gas, thereby giving tangible information as to what losses result from carelessness and lack of attention. Comparisons of operation must include the first steps of the heat balance, as a fewer cubic feet of high B.T.U. gas may be secured from a pound of fuel and operation may not be as good as when more cubic feet of a lower B.T.U. gas are evolved. The heat balance affords a safe comparison of economies, and periodic checks should be made to determine whether operation is stable, getting better or drifting to lower levels.

Table E

Item	B.T.U. per pound of coal as received at 60 deg. F. and 30 inches Barom.	Percent
2—Cold Heating Value of Gas, or Chemical Heat. Useful Heat and Cold Gas Efficiency	9,760	76.8
5—Sensible Heat in Gas Useful Heat	1,373	10.8
Total Useful Heat Hot Gas Efficiency	11,133	87.6
7—Heat Loss; Combustible in Ash	150	1.1
8—Tar and Soot Deposit Heat Loss	133	1.0
10—Heat Loss; Excess Steam	118	1.0
Total Accounted-for Loss	401	3.1
Total Accounted-for Loss plus Useful Heat	11,534	90.8
Difference or Unaccounted-for Loss, Radiation etc.; 12,702 — 11,528	1,168	9.2
Total Loss plus Useful Heat, or B.T.U. entering Producer	12,702	100.0

CARBONIZING COAL IN CURRENT OF GAS

It is generally agreed that the use of gas or steam during the carbonization of coal has an important advantage in rapidly removing from the hot zone primary tar vapors, which are subjected to secondary decomposition when exposed to the high temperatures in that zone. From this standpoint the use of steam appears to be more advantageous because of its high specific heat and because it does not permanently dilute the gas obtained by the carbonization of the coal. Two series of experiments were carried out on different coals. In the first series the influence of the various operating factors, such as the speed of heating on the coal, used in hundred gram charges, was investigated. In the second series of experiments the same tests were made on charges of coal, 7,250 kilograms each. It was found that the use of a current of gas during the carbonization of coal at 400 to 500 degrees C increased the yield of oil. Steam and carbon dioxide have clearly marked effects. The yield in the presence of steam was fourteen per cent of the weight of the coal, while, without steam, it fell to 8.8 per cent. If the results, which are obtained in the carbonization of charges of 100 grams and 7.25 kilograms of the same coal at the same temperature, are compared, it is found that, when neither gas nor steam was used, the shape or design of the retort had a marked effect on the yield of oil. The use of superheated steam increases the yield of oil and also of gas to an appreciable degree.—*J. H. Scholtz and R. V. Wheeler. Fuel, volume, 11 pages 244 to 253*

Deviation of Natural Gas From Boyle's Law

A brief discussion of the theory involved and its application to some gas engineering problems

THE fundamental equation of a perfect gas, expressing the relation between pressure, volume and temperature, is known as Boyle's law. This law states that at constant temperature, the volume occupied by a gas is inversely proportional to the absolute pressure, or $PV = P_1V_1 = K$ in which V is the volume at pressure P, and V_1 is the volume at pressure P_1. In other words, the product of pressure times volume is a constant.

An ideal or perfect gas is one which conforms exactly to Boyle's law. Many common gases conform approximately to this law at ordinary ranges of pressure and temperature but no real gas follows it exactly, and natural gas is no exception. In the natural gas industry there are many problems connected with gas measurement and the estimation of reserves that deal directly with the relationship between pressure and volume. In solving these problems, it is generally assumed by gas engineers that natural gas is a perfect gas, and until recently it was perfectly safe to do this when figuring pipe line capacities, as line pressures rarely exceeded 350# gauge.

The long-distance transmission of natural gas, and the attendant problems dealing with the flow of gas through these pipe lines, gas compression, and accurate estimates of reserves, have become of increased importance. Because of the higher pressures that are used throughout the industry, from the field to the local distributor, consideration of the deviation from Boyle's law is a significant factor in dealing with these problems.

Abstract of Technical Paper 539, U. S. Bureau of Mines, by Johnson and Berwald.

I—Studies Made by Bureau of Mines

An exhaustive study of the deviation of natural gas from the fundamental law has been made by T. W. Johnson and W. B. Berwald, engineers connected with the U. S. Bureau of Mines, Petroleum Experiment Station, Bartlesville, Okla. The investigation was confined to pressures up to 1000# per square inch and at temperatures ranging from 40° to 80° F. Within these ranges of pressure and temperature, natural gas is more compressible; and, conversely, with a decrease in pressure is more expansible than the ideal or perfect gas. As an example, at a constant temperature, 2 cubic feet of a perfect gas measured at 72 pounds per square inch absolute pressure, will expand into a space of 10 cubic feet if the pressure is reduced to 15 pounds per square inch absolute, according to Boyle's law. The experiments show that 2 cubic feet of natural gas, under the same conditions, will expand to a volume somewhat greater than 10 cubic feet.

The relationship, at constant temperature, between the pressure and volume of a gas is known as the compressibility. The departure of the actual pressure-volume relationship from the pressure-volume relationship expressed by Boyle's law is called the "deviation from Boyle's law". The measured volume obtained by reducing the pressure of a definite volume of gas to some standard pressure P_1, minus the volume at the same *standard* pressure derived by Boyle's law from the same *initial* pressure, divided by the initial pressure, gives the deviation from Boyle's law, and may be expressed either as a percentage or a decimal. To obtain the *true* value of the pressure times volume (P_1V_1) at the standard pressure (P_1), the pressure times volume at the given *initial* conditions (PV) is multiplied by a deviation factor of $1 + \frac{n}{100}$, where n is the percentage deviation at pressure P, letting the value of n at P_1 equal zero. From data obtained in the investigation, with P the initial pressure always greater than P_1 the standard pressure, the value of n was found to be always positive; that is, the value of $1 + \frac{n}{100}$ was always greater than 1.

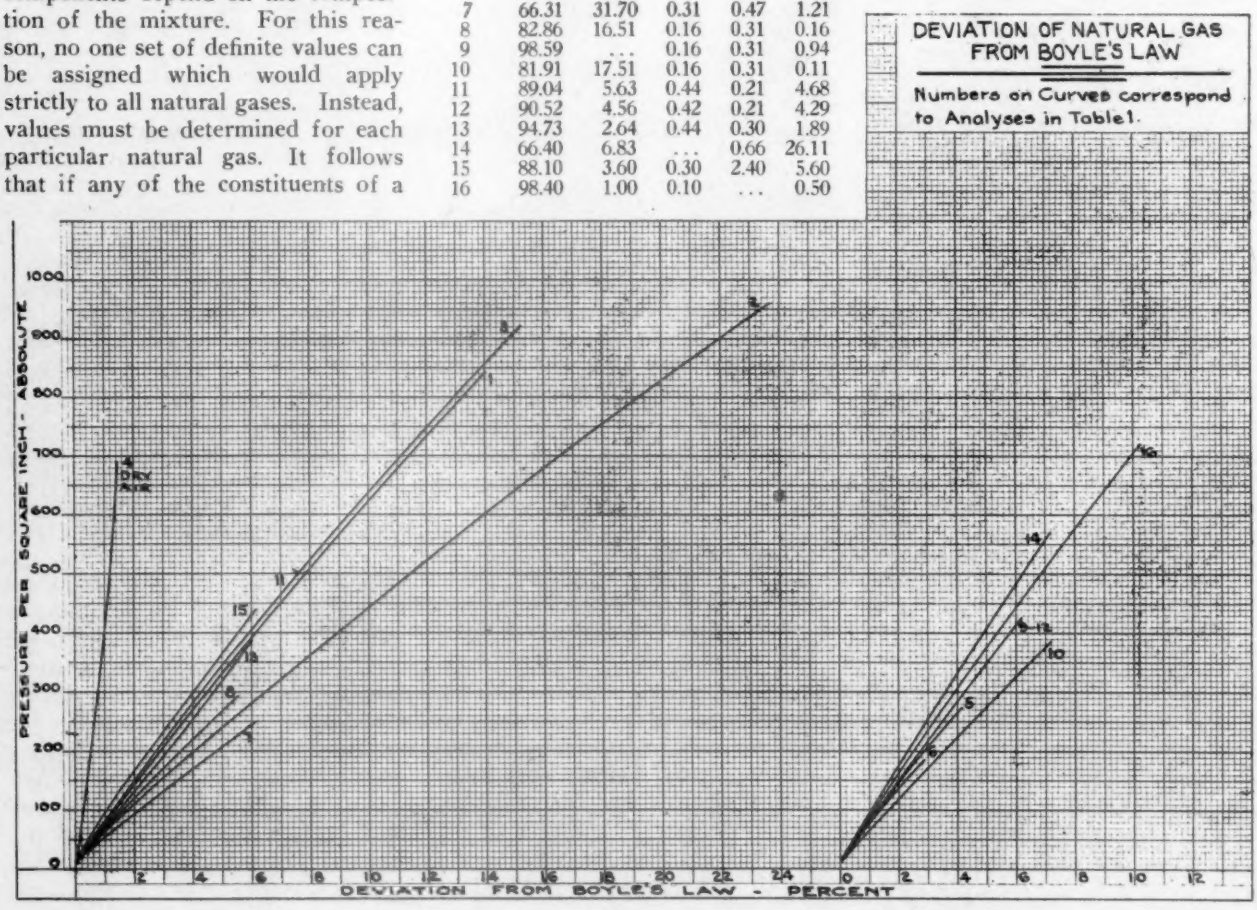
The physical properties and be-

Natural Gas Compressor Station in Louisiana

havior of natural gas are influenced by the relative quantities of the various hydrocarbons and other gases that constitute natural gas. These individual components differ widely from each other in their characteristics and properties; consequently, the properties of a mixture of these components depend on the composition of the mixture. For this reason, no one set of definite values can be assigned which would apply strictly to all natural gases. Instead, values must be determined for each particular natural gas. It follows that if any of the constituents of a gas are removed by liquefaction or otherwise, the chemical composition of the residue is changed and the compressibility likewise changes.

Table 1, Chemical Composition of Natural Gases, per cent

Sample No.	CH_4 (Methane)	C_2H_6 (Ethane)	O_2	CO_2	N_2
1	74.20	18.50	. .	...	7.30
2	67.90	26.10	...	...	6.00
3	82.60	7.20	0.40	2.70	7.10
4	Dry Air	...	...	...	...
5	75.92	10.76	1.10	8.81	3.41
6	88.82	3.20	0.14	0.16	7.68
7	66.31	31.70	0.31	0.47	1.21
8	82.86	16.51	0.16	0.31	0.16
9	98.59	...	0.16	0.31	0.94
10	81.91	17.51	0.16	0.31	0.11
11	89.04	5.63	0.44	0.21	4.68
12	90.52	4.56	0.42	0.21	4.29
13	94.73	2.64	0.44	0.30	1.89
14	66.40	6.83	...	0.66	26.11
15	88.10	3.60	0.30	2.40	5.60
16	98.40	1.00	0.10	...	0.50


DEVIATION OF NATURAL GAS FROM BOYLE'S LAW
Numbers on Curves correspond to Analyses in Table 1.
PRESSURE PER SQUARE INCH - ABSOLUTE
DEVIATION FROM BOYLE'S LAW - PERCENT
DRY AIR

Burrell and Robertson, in Technical paper 158, U. S. Bureau of Mines, 1917, showed that the degree of deviation of the constituent gases of natural gas, is greater for the higher hydrocarbons. That is, gases containing ethane, propane, etc. will have a larger percentage deviation from Boyle's law than one consisting entirely of methane.

Table 1 gives the analyses of a number of different natural gases tested, and curves 1 to 16 show the corresponding deviations.

The foregoing curves are all based on a constant temperature of 60° F. Several determinations were made at other temperatures, and it was found that the more the temperature was increased, the nearer the gas conformed to Boyle's law.

II—The Deviation of Natural Gas from Boyle's Law as Applied to Some Gas-Engineering Problems

The pressure-volume relationship or compressibility of a gas, as commonly used, is not only convenient but is simple in its application. The advantages of simplicity outweigh in many instances the advantages incident to a more exact expression of the relationship. However, there are certain problems in which it is desirable to take account of the deviation, and some of these problems are presented herewith.

Variations in Pressure Base—It is customary in natural gas practice to refer to standard pressure base of 14.4 pounds per square inch absolute. The deviation is calculated from this base as a starting point; that is, at 14.4 pounds the deviation factor is assumed to be unity. In the measurement of gases, particularly in the field, a pressure base of 16.4 pounds is often used. However, as long as the variation in pressure base is relatively small, say within 2 pounds of 14.4, the difference in the deviation factor is small enough to be disregarded. Should it be necessary to take the difference into consideration it may be obtained in the following manner:

Let P = any pressure, pounds per square inch absolute;
V = volume at any pressure P, cubic feet;
V_1 = the volume at pressure base P_1 = 14.4 pounds per square inch absolute, cubic feet;
V_x = the volume at new pressure base of P_x pounds per square inch absolute, cubic feet;
d = deviation factor at P, =

$$1 + \frac{\text{per cent deviation}}{100};$$

d_x = deviation factor at P_x = $1 + \frac{\text{per cent deviation}}{100}$.

The deviation factor at $P_1 = 14.4$ pounds per square inch absolute is unity.

$$\text{Then } V_1 = \frac{V_x(P_x)}{14.4} d_x \text{ or} \quad (1)$$

$$V_x = \frac{(V_1)14.4}{(P_x)d_x} \text{ and} \quad (2)$$

$$V_1 = V\frac{Pd}{14.4} \quad (3)$$

Substituting the value of V_1 from equation (3) in equation (2),

$$V_x = \frac{\frac{VPd}{14.4}\,14.4}{P_x d_x} \quad (4)$$

$$\text{or} \quad V_x = \frac{VPd}{P_x d_x} \quad (5)$$

That is, the deviation factor at any pressure with reference to any pressure base, is equal to the deviation factor for that pressure, referred to the standard base of 14.4 pounds absolute, divided by the factor at the new pressure base. For slight differences in pressure base, such as the difference between 14.4 and 16.4 pounds absolute, the deviation at the new pressure base is determined from the average amount of deviation per pound of pressure based on the deviation at pressure P.

Gas Measurement by Orifice Meter—The general formula for applying the deviation factor, as adopted by the A.G.A. Gas Measurement Committee, is

$$Q = C_1\sqrt{HP\left(1 + \frac{n}{100}\right)} \quad (6)$$

in which

n = per cent deviation at the mean absolute pressure and temperature of measurement;

Q = rate of flow, cubic feet per hour;

H = the differential pressure across the orifice in inches of water;

P = the absolute static pressure, pounds per square inch;

C_1 = the orifice meter coefficient.

This is the orifice meter formula as commonly used, multiplied by the square root of the deviation factor. The orifice meter coefficients C_1 have been experimentally determined with gas or air, both at low and high pressures and the amount of deviation from Boyle's law has been considered when arriving at the values of the coefficients. In other words, the coefficient C_1 is applicable to a deviation factor of unity and coefficients obtained in experimental studies are reduced to this basis before they are published.

The following example illustrates the application of the correction to orifice measurement and is based on the compressibility data in table 1 and curve 1.

C_1 = 1,112.2 = orifice coefficient for a 2-inch orifice in an 8-inch line; 0.60 specific gravity, 60° F., and 14.65 pounds per square inch absolute pressure base;

H = 15″ water;

P = 460 pounds per square inch absolute;

n = 7.20 per cent at 460 lbs. abs.

Then

$$Q = 1{,}112.2\sqrt{15 \times 460\left(1 + \frac{7.20}{100}\right)}$$

= 95,650 cubic feet at 14.65 pounds per square inch absolute base pressure.

If the correction factor were not applied

$$Q = 1{,}112.2\sqrt{15 \times 460} = \frac{92{,}386}{\text{cubic feet.}}$$

a difference of about 4½ per cent.

In calculating flow over a specific time period, or number of hours, it is immaterial whether the correction factor is applied to each hourly reading or to the average of the sum of the readings, as the results agree closely enough for all practical purposes. When static pressure varies more accurate results are obtained for the total volume where each individual $\sqrt{HP}$ value is multiplied by the square root of the deviation factor at the pressure during that period. If the static pressure remains constant, the two methods of calculation give identical results, regardless of any changes in the differential pressure H. When both the static and differential pressures change, the difference between the two methods of calculation depends on the amount of change in both pressures. In extreme cases, this difference may amount to 0.5 per cent.

Gas Measurement by Positive Meter—In the use of positive displacement meters, where actual volumes are measured and reduced to standard conditions by applying direct pressure ratios, the deviation may be taken into account as follows:

$$V_1 = V\frac{P}{P_1}d \text{ (units as in equations 1-5)} \quad (7)$$

assuming P = 100, P_1 = 14.4, V = 500 and d = 1.0125

$$V_1 = 500 \times \frac{100}{14.4} \times 1.0125$$

= 3,515 cubic feet.

Gas Measurement by "Non-critical Flow Prover"—In many cases, gas is measured with a "non-critical flow prover", in which gas flows through an orifice direct to atmosphere under conditions such that the ratio between the atmospheric pressure and the absolute upstream pressure is greater than about 0.5. The fundamental formula is

$$Q = C\sqrt{P_1(P_1 - P^2)} \text{ or}$$

$$Q = C\sqrt{P_2(P_1 - P^2)} \quad (8)$$

where Q = rate of flow, cubic feet;

C = orifice coefficient, applicable for deviation factor of unity;

P_1 = upstream pressure, in convenient units;

P_2 = downstream pressure, in same units as P_1.

The value of the coefficient C must change in conformity with the change

from P_1 to P_2, depending on which equation is sued.

The correction due to deviation is the same as for any orifice meter, that is, the value of $C\sqrt{P_1 (P_1 - P_2)}$ or $C\sqrt{P_2 (P_1 - P_2)}$ is multiplied by $\sqrt{1 + \frac{n}{100}}$, where n = percent of deviation.

Gas Measurement by "Critical flow prover"—There is a condition of flow of gas through an orifice, in which the volume of gas being measured depends only on the upstream pressure on the orifice. This condition is known as the critical flow and occurs when the ratio between the downstream and upstream pressures is less than about 0.5. The flow is direct to the atmosphere and the principle of critical flow applies to all upstream pressures in excess of about 28 pounds per square inch absolute.

The fundamental equation is

$$Q = \frac{CP}{\sqrt{GT}} \qquad (9)$$

where

- Q = rate of flow;
- C = coefficient, applicable for deviation factor of unity;
- P = absolute upstream pressure;
- G = specific gravity (air = 1.00);
- T = absolute temperature, degrees F.

The inclusion of the deviation factor is similar to that for orifice meter measurement, thus

$$Q = \frac{CP}{\sqrt{GT}} \sqrt{1 + \frac{n}{100}} \qquad (10)$$

Estimating Gas Reserves—There are two methods generally used for estimating gas reserves in sand bodies, commonly called the "porosity-area method," and the "pressure-volume method." The porosity-area method is based on the porosity, thickness, productive area and rock-pressure of the sand. The pressure-volume method is based on a decline in rock pressure and on the volume of gas producing the decline.

Porosity-Area Method—The formula for the amount of gas in the sand by this method is

$$V = AtS \frac{P}{P_o} \qquad (11)$$

where

- V = volume of gas at pressure base P_o contained in the reservoir;
- A = productive area, square feet;
- t = thickness of sand, feet;
- S = porosity of sand, expressed decimally;
- P = rock pressure, pounds per square inch, absolute;
- P_o = pressure base, pounds per square inch absolute.

In the above formula (11) it is assumed that the gas follows Boyle's law. Since the correction for the deviation is a function of the pressure, the pressure P is multiplied by the deviation factor and formula (11) becomes

$$V = AtS \frac{Pd}{P_o} \qquad (12)$$

where d is the deviation factor at P.

In natural gases d is greater than unity, consequently the volume by equation (12) will be *larger* than that computed by equation (11). In other words, the amount of gas in a sand body computed by the porosity-area method, without considering the deviation, is *less* than that calculated when the deviation is taken into account.

Pressure-volume Method — The basic formula for the amount of reserve gas in a structure, based on the known volume produced for a known pressure drop, assuming that the gas follows Boyle's law is

$$V = Q \frac{P_2 - P_t}{P_1 - P_2} \qquad (13)$$

where V = volume of gas remaining in the sand, between the rock pressure P_2 and the final pressure on the sand, in cubic feet at atmospheric pressure;

- Q = volume of gas produced during a decline in rock pressure from P_1 to P_2;
- P_2 = final rock pressure of the decline;
- P_1 = initial rock pressure of the decline;
- P_t = pressure in the sand at abandonment.

The derivation of the formula which takes the deviations into account is as follows:

The volume V_1 in the reservoir at pressure P_1, reduced to base pressure P_o, is

$$V_1 = C \times \frac{P_1 d_1}{P_o} \qquad (14)$$

where d_1 = the deviation factor at P;

C = the volume of void space in the sand body.

Similarly, the volume V_2 in the reservoir at pressure P_2, reduced to pressure base P_o, is

$$V_2 = C \times \frac{P_2 d_2}{P_o} \qquad (15)$$

Where d_2 = the deviation factor at P_2

Then, $V_1 = V_2 = Q$ = the volume of gas causing the drop in pressure from P_1 to P_2. This volume, which is usually an actual metered quantity, is either measured at a pressure where the deviation is negligible, or at high pressures where the deviation should be taken into account.

Therefore,

$$Q = \left(C \times \frac{P_1 d_1}{P_o}\right) - \left(C \times \frac{P_2 d_2}{P_o}\right), \text{ or}$$

$$Q = \frac{C}{P_o} (P_1 d_1 - P_2 d_2), \text{ or}$$

$$C = \frac{QP_o}{P_1 d_1 - P_2 d_2} \qquad (16)$$

The volume V_t remaining in the reservoir at pressure of abandonment P_t is

$$V_t = C \times \frac{P_t d_t}{P_o} \qquad (17)$$

The volume V to be recovered is equal to $V_2 - V_t$, or

$$V = \left(C \times \frac{P_2 d_2}{P_o}\right) - \left(C \times \frac{P_t d_t}{P_o}\right) \text{or}$$

$$V = \frac{C}{P_o} (P_2 d_2 - P_t d_t) \qquad (18)$$

Substituting in equation (18) the value of C from equation (16)

$$V = \left(\frac{QP_o}{P_1 d_1 - P_2 d_2}\right)\left(\frac{P_2 d_2 - P_t d_t}{P_o}\right),$$

(Continued on page 48)

ELEMENTS OF GAS TECHNOLOGY

Combustion of gases

THE combustion of gases is a highly complex subject and is one upon which there has been, and still is, an enormous amount of research. The reader who is interested in a complete and exhaustive treatment of gas combustion is referred to "Fuels and Their Combustion" by Haslam and Russell, published by the McGraw-Hill Book Company, and the third edition of "Combustion," C. George Segeler, Editor, published by the American Gas Association. Many excellent papers of the U. S. Bureau of Mines and the U. S. Bureau of Standards are also available, as well as hundreds of other books and technical papers dealing with the subject as a whole or with some particular phase of it.

Primarily, combustion is a phase of oxidation. It is the chemical union of oxygen with materials capable of being burned, and is characterized by the rapid production of heat and in most cases, by the evolution of light. Slow oxidation, such as the formation of rust on iron, produces just as much heat as if the corresponding amount of iron were actually burned, but as the time element of the chemical action is so much longer, the heat is dissipated and the material never reaches the point of actual ignition. It frequently happens that some combustible substances are poor conductors of heat, such as waste, oily rags, piles of papers, hay, coal piles and even rock dumps from mines, if the rock contains an appreciable amount of sulphur compounds. Substances such as these particularly when damp and exposed to the air, often develop such heat from slow oxidation that they finally reach the ignition temperature and burst into flame. This process of slow oxidation and subsequent ignition is generally termed "spontaneous combustion," but it is anything but spontaneous.

The process of combustion is a definite chemical change, hence the reactions involved account for definite quantities of combustible material and the resultant products, as well as perfectly definite amounts of heat, which are always the same for the same combustible materials. The products of complete combustion are, for carbonaceous substances, carbon dioxide and water vapor. If sulphur is present, sulphur dioxide or trioxide will also be formed. When substances react chemically heat is always given off or absorbed. This heat is called the "heat of reaction" and in the American system is expressed in B.t.u. per pound-mol, per pound and in the case of gases, very often in B.t.u. per cubic foot. There are two heat values for every combustible; the gross heat value, which assumes that the products are cooled back to the initial temperature and the water vapor condensed; and the net heat value, which assumes that the products are cooled back to the initial temperature, but the water *not* condensed. The difference between these values is equivalent to the heat of vaporization of water *at the initial temperature*. Table 4 gives the heats of reaction of a number of common combustibles.

Table 5 gives gas combustion constants and data for some of the principal gases encountered in commercial gas practice. Note that these data are all on a dry basis, and that when dealing with gases saturated with water vapor, a correction must be made, if exact results are required. For example, one cubic foot of *dry* methane weighs .04243 pounds. When saturated with water vapor at 60° F., 1.73% of the space is occupied by water vapor and the true amount of methane in one cubic foot would therefore be .9827 times .04243 or .04170 pounds. The amount of water vapor present is .0173 times .04758 (the weight of 1 cu. ft. water vapor) or .0082 lbs. Therefore, one cubic foot of methane, saturated at 60° F., will weigh .04170 plus .0082 or .04252 lbs.

At any temperature, there is a definite amount of water vapor which a gas can hold. Table 6 gives the amount of water vapor, in per cent by volume, in a saturated mixture.

TABLE 4

Heats of Reaction and Common Combustibles

Substance	*Reaction*	*Heat of Reaction B.t.u. per Mol. at 60° F. & 30" Hg. Dry* Gross	Net
Carbon to CO	$C + \frac{1}{2}O_2 = CO$	+ 47,358	+ 47,358
Carbon to CO_2	$C + O_2 = CO_2$	+ 169,686	+ 169,686
Carbon plus CO_2	$C + CO_2 = 2CO$	— 74,970	— 74,970
Carbon plus H_2O	$C + H_2O = CO + H_2$		— 56,718
Carbon plus H_2O	$C + 2H_2O = CO_2 + 2H_2$		— 38,466
CO_2 + Hydrogen	$CO_2 + H_2 = CO + H_2O$		— 18,252
CO + Oxygen	$CO + \frac{1}{2}O_2 = CO_2$	+ 122,328	+ 122,328
CO + water	$CO + H_2O = CO_2 + H_2$	— 792	
Hydrogen	$H_2 + \frac{1}{2}O_2 = H_2O$	+ 123,120	+ 104,076
Sulphur to SO_2	$S_2 + 2O_2 = 2SO_2$		+ 248,400
Sulphur to SO_3	$S_2 + 3O_2 = 2SO_3$		+ 40,680
Methane	$CH_4 + 2O_2 = CO_2 + 2H_2O$	+ 383,107	+ 345,019
Ethylene	$C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$	+ 613,424	+ 575,336
Ethane	$C_2H_6 + 3\frac{1}{2}O_2 = 2CO_2 + 3H_2O$	+ 667,426	+ 610.294
Propane	$C_3H_8 + 5O_2 = 3CO_2 + 4H_2O$	+ 950,102	+ 873,926
Butane	$C_4H_{10} + 6\frac{1}{2}O_2 = 4CO_2 + 5H_2O$	+ 664,550	+ 569,330
Acetylene	$C_2H_2 + 2\frac{1}{2}O_2 = 2CO_2 + H_2O$	+ 561,194	+ 542,150
Benzene	$C_6H_6 + 7\frac{1}{2}O_2 = 6CO_2 + 3H_2O$	+1,416,532	+1,359,400
Hydrogen Sulphide	$H_2S + 1\frac{1}{2}O_2 = SO_2 + H_2O$	+ 254,878	+ 235,834

Note:—Plus sign indicates heat is evolved; negative sign indicates heat to be added.

TABLE 6*

Percent of H_2O Vapor by Vol. in Saturated Mixture at 30" Hg

Temp. °F.	% H_2O	°F.	% H_2O	°F.	% H_2O	°F.	% H_2O
0	.13	50	1.20	78	3.20	106	7.67
5	.16	52	1.29	80	3.42	108	8.12
10	.21	54	1.40	82	3.65	110	8.60
12	.24	56	1.50	84	3.89	112	9.08
15	.27	58	1.61	86	4.15	122	12.17
20	.34	60	1.73	88	4.42	132	15.95
22	.37	62	1.86	90	4.70	142	20.61
25	.43	64	1.99	92	5.00	152	26.51
30	.55	66	2.14	94	5.33	162	33.70
32	.60	68	2.28	96	5.67	172	42.68
35	.67	70	2.44	98	6.03	182	53.40
40	.82	72	2.61	100	6.41	192	66.34
42	.89	74	2.79	102	6.81	202	81.83
45	.99	76	2.99	104	7.22	210	96.00

* *From A.G.A., "Combustion," 3rd Edition.*

TABLE 5

Gas Combustion Constants and Data

No.	Gas	Chemical Formula	Molecular Weight	U. S. Standard 32° F. and 760 mm Hg. Specific Wt. lbs. per Cu. Ft.	U. S. Standard 32° F. and 760 mm Hg. Specific Vol. Cu. Ft. per Lb.	A.G.A. Standard 60° F. and 30″ Hg. Specific Wt. lbs per Cu. Ft.	A.G.A. Standard 60° F. and 30″ Hg. Specific Vol. Cu. Ft. per Lb.	Specific Gravity Air = 1.000	Cubic Feet per Mol 32° F. and 760 mm	Cubic Feet per Mol 60° F. and 30″	Heat Value—at 60° F. and 30″ Hg. Dry B.t.u. per Cu. Ft. Gross	Heat Value—at 60° F. and 30″ Hg. Dry B.t.u. per Cu. Ft. Net	Heat Value—at 60° F. and 30″ Hg. Dry B.t.u. per Pound Gross	Heat Value—at 60° F. and 30″ Hg. Dry B.t.u. per Pound Net	Mean Specific Heats B.t.u. per Pound per Degree F. C_p	C_v	$C_p - C_v$	$\frac{C_p}{C_v}$	Temperature Limits °F.
1	Air	$O_2 + N_2$	28.966	.08071	12.390	.07655	13.063	1.000	358.9	378.4					.2399	.1716	.0683	1.398	70-212
2	Oxygen	O_2	32.000	.08921	11.210	.08461	11.819	1.1053	358.7	378.2					.2213	.1575	.0638	1.405	70-212
3	Nitrogen	N_2	28.016	.07807	12.809	.07439	13.443	.9672	358.9	376.6					.2474	.1767	.0707	1.400	70-212
4	Hydrogen	H_2	2.016	.005611	178.221	.005327	187.723	.06952	359.3	378.4	323.5	275.1	61,100	51,643	3.4226	2.4306	.9920	1.408	70-212
5	Carbon Monoxide	CO	28.000	.07804	12.814	.07404	13.506	.9669	358.8	378.2	323.5	323.5	4,369	4,369	.2493	.1775	.0718	1.405	70-212
6	Carbon Dioxide	CO_2	44.000	.12341	8.103	.11704	8.544	1.5290	356.5	375.9					.2032	.1575	.0457	1.290	70-212
7	Hydrogen Sulphide	H_2S	34.076	.09608	10.408	.09109	10.979	1.1898	354.7	374.1	672	591	7,479		.2453	.1893	.0560	1.296	70-212
8	Sulphur Dioxide	SO_2	64.06	.18272	5.473	.1733	5.770	2.2638	350.6	369.6					.1514	.1174	.0340	1.290	59
9	Methane	CH_4	16.031	.04475	22.346	.04243	23.565	.5543	358.2	377.8	1,014.7	913.8	23,912	21,533	.5963	.4728	.1235	1.261	70-212
10	Ethane	C_2H_6	30.046	.08469	11.808	.08029	12.455	1.04882	354.8	374.2	1,781	1,631	22,215	20,312	.3861	.3165	.0696	1.220	59
11	Propane	C_3H_8	44.062	.1261	7.930	.1196	8.365	1.5617	349.4	368.6	2,572	2,371	21,564	19,834	.4099	.3627	.0472	1.13	60
12	Iso-Butane	C_4H_{10}	58.078	.16687	5.993	.1582	6.321	2.06654	348.1	367.1	3,251	2,999	21,247	19,606	.3697	.3331	.0366	1.11	59
13	n-Butane	C_4H_{10}	58.078	.16837	5.939	.1582	6.321	2.06654	344.9	367.1	3,353	3,102	21,247	19,606					
14	n-Pentane	C_5H_{12}	72.092	.2110	4.739	.1904	5.252	2.4872		378.6	3,981	3,679	20,908	19,322	.4089	.3765	.0324	1.086	187
15	n-Hexane	C_6H_{14}	86.107	.2553	3.917	.2274	4.398	2.9704		378.7	4,667	4,315	20,526	18,976	.3646	.3376	.0270	1.08	176
16	Ethylene	C_2H_4	28.031	.07868	12.710	.07456	13.412	.9749	356.3	376.0	1,631	1,530	21,884	20,525	.3996	.3317	.0679	1.205	70-212
17	Propylene	C_3H_6	42.046	.1192	8.389	.1110	9.007	1.4504		378.7	2,336	2,185	21,042	19,683					
18	Butylene	C_4H_8	56.062	.1611	6.207	.1480	6.756	1.9336		378.8	3,135	2,884	20,840	19,481					
19	Acetylene	C_2H_2	26.016	.07323	13.656	.06971	14.344	.9073	355.3	373.2	1,503	1,453	21,572	20,840	.3844	.3113	.0731	1.235	59
20	Benzene	C_6H_6	78.046	.2174	4.600	.2060	4.852	2.6920	359.0	378.7	3,741	3,590	18,150	17,418	.3203	.2947	.0256	1.087	194
21	Toluene	C_7H_8	92.062	.2784		.2431	4.113	3.1760		378.7	4,408	4,206	18,129	17,301					
22	Xylene	C_8H_{10}	106.077								5,155		18,410						
23	Naphthalene	$C_{10}H_8$	128.062								5,859		17,298						
24	Ammonia	NH_3	17.031	.04818	20.756	.04563	21.914	.5969	353.5	373.2	433		9,598		.5219	.4069	.1150	1.283	70-212
25	Water Vapor	H_2O	18.016	.05018	19.932	.04758	21.017	.6215	359.1	378.6									
26	Sulphur Vapor	S_2	64.12	.2435	4.107						1,070	1,070							
27	Average Natural Gas (Under 20% Ethane)		17.852	.04991	20.037	.04733	21.128	.6183	357.7	377.2	1,026	925	21,677	19,543	.5407	.4293	.1114	1.259	70-212
28	Average Natural Gas (Over 20% Ethane)		20.421	.05724	17.469	.05428	18.423	.7091	356.7	376.2	1,184	1,071	21,813	19,731	.4947	.3962	.0985	1.249	70-212
29	Average Coke Oven Gas		11.586	.03234	30.921	.03069	32.584	.4008	358.3	377.5	575	515	18,736	16,781	.6914	.5226	.1688	1.323	70-212
30	Average Coal Gas		12.402	.03461	28.893	.03284	30.451	.4289	358.3	377.7	570	512	17,357	15,591	.6487	.4882	.1605	1.329	70-212
31	Average Carburetted Water Gas		18.576	.05184	19.289	.04919	20.330	.6424	358.3	377.7	545	504	11,080	10,246	.4296	.3225	.1071	1.332	70-212
32	Low Gravity Carburetted Water Gas		15.554	.04340	23.039	.04118	24.282	.5378	358.3	377.7	548	501	13,307	12,165	.4497	.3302	.1195	1.362	70-212
33	Average Blue Water Gas		15.754	.04394	22.760	.04170	23.981	.5446	358.6	377.8	299	274	7,170	6,571	.4460	.3189	.1271	1.399	70-212
34	Blue Water Gas (Bituminous)		20.075	05599	17.859	.05321	18.794	.6944	358.5	377.3	261	240	4,905	4,511	.3605	.2611	.0994	1.381	70-212
35	Average Oil Gas		11.749	.03280	30.492	.03112	32.137	.4065	358.3	377.6	548	492	17,611	15,811	.6736	.5042	.1694	1.336	70-212
36	Average Producer Gas		25.052	.06986	14.314	.06645	15.049	.8660	358.3	377.6	146	138	2,197	2,077	.2837	.2042	.0795	1.389	70-212
37	Average Blast Furnace Gas		29.200	.08146	12.276	.07747	12.908	1.0110	358.5	376.9	98	97	1,265	1,252	.2455	.1773	.0682	1.385	70-212
	Solid																		
	Carbon	C	12.000										14,140	14,140					
	Sulphur	S	32.06										3,982	3,982					

NOTES: Molecular Weights based on Atomic Weights as given in International Critical Tables. Molecular Weights of Nos. 27 to 37 inclusive computed from average analyses. Specific Weights and Volumes at 32° and 760 mm. from U. S. Bureau of Standards; Specific Weights and Volumes at 60° and 30″ from A.G.A. "Combustion," 3d Edition, except Nos. 27 to 37 inclusive, calculated from average analyses.

Heats of Combustion from A.G.A. data and U. S. Bureau of Standards, on dry basis. For more exact values with saturated gases, deduct 1.73% from B.t.u. values to correct for H_2O vapor. Heats of Combustion of Nos. 27 to 37 inclusive calculated from average analyses.

Gross Heat Values computed from net by allowing for heat of vaporization of water at 60° F., amounting to 50.3 B.t.u. per Cu. Ft. or 1057.8 B.t.u. per Lb. of water vapor.

Mean Specific Heats from U. S. Bureau of Standards, International Critical Tables, and Partington & Schilling, "Specific Heats of Gases", except Nos. 27 to 37 inclusive, which are calculated from analyses.

Effective Advertising Appeals

Analyzed by the Copywriter

VACATION

EVERYBODY loves a vacation.

Vacations are as necessary to a happy normal life as food, clothing and sleep. Their purpose is to relieve the tension that slowly but surely grows upon us in the pursuit of routine affairs. Even the man and woman who, as the saying goes, "thrives on work" sooner or later finds the necessity for some form of relaxation. It may not be a vacation in the ordinarily accepted sense of a trip to the country. It may be only a change of pace, a new interest, a different kind of activity; but if it results in a refreshed return to the business of life and living, it has earned the attributes of a vacation period. In this sense, let us analyze the vacation mood and see what it can do for our advertising.

"PALM BEACH in Your Bathroom—for $3 a Month" an advertisement shouts to us out of the headlines of a daily newspaper. It's an advertisement for a gas water heater advising us that Palm Beach is only two minutes away, wherever we are, if we go by way of the bathroom that is connected to an automatic storage heater. "Lots of our best people are going south this way." The idea has merit when we read it in February. Today we are looking closer. Ah—here we have it!

"Are You Still Roughing It at Home?" That reminds us that there are, generally, two classes of people. The first leave the comforts of modern plumbing and utility service in order to spend the holidays chopping wood for the campfire and lugging water from a stream a half-mile away. The second class travels in de luxe pullmans, stops at all the first class hotels, and returns to a house where the stairs are worn with the feet of many trips back and forth to a cellar where the water is still heated by hand. Camping under the stars has something in its favor. Camping at home can become fearfully monotonous. Your parting guests, when they say "Goodbye," do they also think—"You Must Come and Camp with *Us* Sometime!"? It is a good thought to play with.

"Take a Vacation from Water Heating Cares." That kind of a vacation is permanent. It makes at least a moderate investment seem well worth while—like spending a few dollars today for the sake of a retirement fund in old age. If you have been playing nurse maid to a refractory water heater the best years of your life, you are entitled to this sort of a vacation. So is the old water boiler. Why not trade it in?

"Let's Go Places!" Do you read the travel news and wish you could get away at a moment's notice? What is it that usually prevents. . . . .outside of the children and lack of money, of course? Most of it's the thought of shutting down the furnace, stopping the ice man and all the other petty details of interrupting a running machine. A truly automatic household—and that includes electricity as well as gas—solves the going-away problem. "Home again!" How else can you be sure of coming home to a warm house, the comforts of hot water, and a good supply of fresh food safely tucked away, ready to be cooked by merely setting a dial? Going places has lost its terrors and allowed us to realize its delights. "Treat Yourself This Summer to a Worryless Vacation!"

Even if you stay at home, it is possible to enjoy many of the benefits of a real vacation. In fact, we are acquainted with people of limited income who say quite cheerfully that they would rather spend their vacation money in buying a new labor-saving appliance than frittering it away on a seashore hotel. With self-action equipment in the home, they can enjoy many extra vacation hours every week for the rest of their lives. For example, "Take A Vaca-

***The Jones family can go away for days* without worrying about their furnace**

AUTOMATIC gas heating is safe-free, trouble-free heating. It eliminates all furnace tending and furnace drudgery. It is as certain and dependable as gas cooking, and no more costly than other methods of heating, if all factors are considered.

You light the pilot in the fall and turn it off in the spring. No further attention is required save the occasional setting of the thermostat. Move the lever of the thermostat to any temperature desired. This temperature will be maintained constantly . . . even in the coldest weather. You can go away for days and return to a home that is as warm and cheerful as it was the day you left and not a water pipe will be frozen!

Your home is never below summer heat . . . nor is it ever uncomfortably hot. The temperature is even . . . constant . . . uniform. This means better health for the entire family . . . less danger of contracting colds, grippe, influenza and other ailments which often result from overheating and underheating.

YOUR FURNACE CLEANED FREE

Let us tell you how little it will cost to convert your furnace or boiler into an automatic gas-fired heating plant. $15 down. Small monthly payments. Your furnace cleaned free if you buy now. Offer expires October 31st. Estimate of operating cost furnished free. Booklet sent on request.

THE GAS COMPANY

Leaving Worries Behind

tion from Kitchen Heat;" or "SAVED! a Two Weeks' Vacation Each Year with Gas for Cooking." Perhaps "Two Weeks is Not Enough for Vacation." You can play it either way and get results.

Each member of the household has his or her own idea of what a vacation should be. A whole story could be written concerning what happens when Mrs. Homemaker goes away for a holiday, leaving Mr. Homemaker to fend for himself. "When Mother Took a Vacation—Father Soon Saw the Need of a New Gas Range." A few burns, cuts and aching muscles made him see the need for a lot of things that the family had been talking about vainly for months and years. Today, with the new automatic gas range installed, "X Marks the Spot Where Mother Used to Stand." Next time. "Let Mother Enjoy the Holidays Too."

On the other hand, when father travels—on business of course—he can say to the girl he leaves behind, "Now You Won't Have to Tend Fire While I'm Away."

The Best Advertising

The best kind of advertising, generally speaking, is that which succeeds in realizing one's unspoken wishes and thoughts. Dreams, too, are a kind of vacation; in fact, most dreams are said to be dreams of release. "Don't *Wish* To Go To That Party—GO!" Let automatic gas appliances run the home while you're away. "Go! (here's a chance to use the green traffic light) Enjoy Your Freedom."

Then, too, each season of the year has its own vacation mood. In winter—"When Winter's Warmth Is Like Summer's Sun"—we speak of gas heating "As Automatic As June Sunshine" . . . ."As Clean as June Sunshine—and As Comfortable." Or, again: "Have June Weather in Your Home All Winter Long." But the fall is the significant time, when household duties begin to weigh heavily once more after a few months of relaxation. Then you can ask the question, "When Autumn Seeks a Partner, Do You Have Time to Play?" Thousands of women have gained leisure for mental and physical refreshment by automatically simplifying kitchen routine—with gas. Finally, there is the current season:—"Step Out with Spring! New Life, New Bloom, New Vigor. All the World Renews Its Youth in Spring! Put New Youth into Your Stride."

An Inexpensive Trip to Palm Beach

Perhaps we need a trifle more emotional excitement in our advertising. It wouldn't be bad.

The chief value that modern gas appliances have for the woman of today is not merely that they create leisure, but even more the fact, that while she is enjoying that leisure, she can feel confident her household machinery is running smoothly and efficiently, as much so as if she were there herself. In a very real sense, therefore, she can say, "My Gas Range Does My 'Staying Home' for Me!" The advertising man echoes her words in a message to other women—"Don't Stay at Home;" Gas Service Works While You Play;" "Dinner Is Cooking While You Play;" "Enjoy the Afternoons While Your Dinner Is Cooking."

Here you might as well extend the afternoon into a week-end and include the entire family. Here they all are, with "The Lady at the Wheel," enjoying the country and seashore as never before. Or, if it's winter, "The Jones Family Can Go Away for Days at a Time Without Worrying About Their Furnace." Off on a week-end! "But Food Is Safe at Home in a Gas Refrigerator." Three-day week-ends. "Home Monday Evening to a Supper Prepared Friday Morning." It's a great life—even when you week-end.

Each gas appliance has its own vacation theme that can be drawn upon by the astute advertiser. What is the gas refrigerator, for example, but

(Continued on page 30)

Are YOU *Using the* *INSTITUTIONAL THEME* *in* YOUR *WINDOW DISPLAYS?*

A To-the-Point Consideration of this Neglected Activity

By STUART BRATESMAN

Manager, Display Dept., Boston Consolidated Gas Company

THE institutional value of window displays has been one of the sadly neglected activities in the gas industry. It seems to this writer that gas companies have more to tell in their windows than mere merchandising messages of appliances. Why not tell the whole story of gas?

Window display advertisements that educate the public, play a big part in the program of building good will between the consumer, or the man on the street, and the gas company.

A carefully planned and executed series of institutional displays has a lasting effect on the public. Tell the man on the street the whole story of

gas. Talk to the housewife, through your windows, about the many conveniences and comforts of this modern fuel. The windows of the average gas company are in full view of the public 24 hours every day. They differ from printed advertising that is seen just once and then thrown away. Window displays are a constant reminder of the possibilities and vastness of gas service.

A lot is to be told about gas that most people are totally unaware of; if you were to approach the average man on the street he would be at a loss to tell you anything about gas, other than that his wife uses it for cooking and he pays a bill once a month. Our competitors are stressing service at every turn . . . why can't we? Our product is certainly of a more colorful nature and has a certain romance attached to it. Utilize your windows for this important work.

RESEARCH
RESEARCH PLAYS AN IMPORTANT PART IN BRINGING THE BEST IN GAS SERVICE AND MODERN APPLIANCES TO YOUR HOME, SHOP OR FACTORY
LET OUR ENGINEERS HELP WITH YOUR HEATING PROBLEMS
USE GAS THE BETTER FUEL

Take a look at the three educational window sets shown on these pages. They took just as much time to prepare as the regular type of appliance display. They were part of a regular scheduled program of institutional advertising that is still in effect.

Displays of this type create interest . . . unusual interest, because they present the story of gas in terms of something else besides new appliances.

There was a big appeal in the display with the giant head of the housewife speaking her little piece about gas. The eyes, looking directly at the reader, caught and held your attention, and the headline did its job in creating interest as well. The simile of the huge thermos bottle told the story of gas service quickly and effectively in the next window display. The bungalow and skyscrapers were built on a ledge, to give emphasis and realism to the gas pipes underneath. A new note was introduced in the other educational set. The gas flame under the retort was painted on cloth and illuminated from behind to give a striking effect, especially at night.

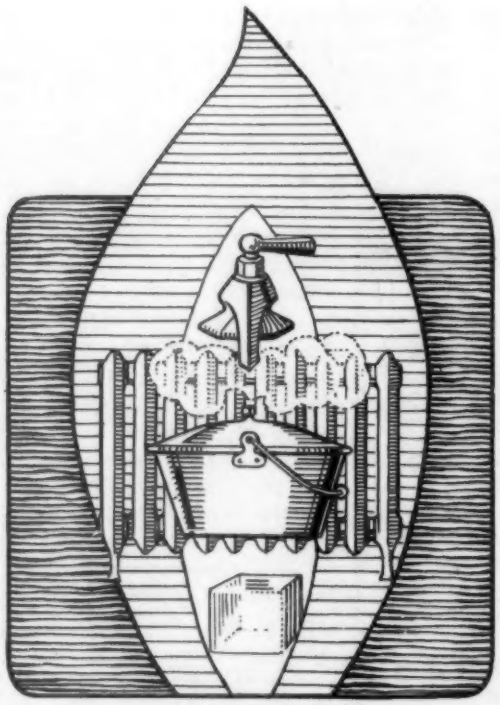
From these thoughts it is hoped more emphasis will be directed, in the future, towards using windows as a means of education. Consider this reasonable and effective medium; and remember window displays cost less to prepare than other forms of advertising, and reach thousands at the point of purchase . . . your own building.

Effective Advertising Appeals

(Continued from page 28)

"An Escape Into Silence?" "Quiet as a Country Evening!" The modern gas range urges you to "Come Out of the Kitchen" on these beautiful spring and summer days. Around Thanksgiving and Christmas, Mrs. Homemaker has her choice between "Holiday Cooking or a Cooking Holiday." Likewise, many summer vacations have been ruined by worrying over next winter's heating problem. One gas company built up an entire series of advertisements around the slogan "Carefree Summer Days, Why Not Carefree Winter Days?" "Does the Shadow of a Shovel Cloud Your Summer Days?"

The lure of relaxation from arduos household duties is common to almost all advertisers from silk hosiery to conducted tours. But it is made especially for the gas industry, whose major services are the real answer to many a housewife's prayer. Think of the gratitude in the heart of the woman who, after years of feeling the urge to get out in the open, hears addressed to her: "This Summer You Are Going To Get the Rest and Recreation You Need!" Time, at last, "For the Things You'd Rather Do." Good will and good business follow the gas company that advertises and sells its customers, through the use of automatic appliances, "A PERMANENT VACATION."



PROFITABLE POINTERS

WE have been conducting a private survey during the past six months, having heard it said that direct mail advertising that follows keyed newspaper and magazine advertising falls down. Our survey consisted in reading advertisements that invited the consumer to make further inquiry for booklets or samples or particulars about various merchandise. And we wrote and wrote, and while some requests and inquiries brought no reply at all, others brought booklets or samples, but no prices or no dealers' name; others said "we have mailed your request to our ..... and have asked our representative to call on you with full details and prices" ——but the representative did not show up. We hope you gas men who employ keyed inquiries, letters, or coupons follows through; and that when you get an inquiry you will send a salesman to give the customer facts and figures or, if you cannot do this, that you will at least furnish the prospective purchaser with detailed information in regard to the merchandise advertised and give him prices and terms. As we view it, advertising has not failed but the human element is at fault.

COOKING Schools seem to be the vogue again. Some gas men say that while these schools draw large crowds, it is very difficult to trace sales directly to these public demonstrations (usually conducted by outside promoters). These men are of the opinion that smaller numbers of women assembled either in their own stores or at private gatherings of clubs, are productive of much more satisfactory results, to say nothing of the direct sales made and the number of live prospects secured.

HERE is a window trim by Ray Martin of New York Consolidated Gas Company which, in our opinion, scores a ten strike. Besides containing considerable of the best sort of water heating for cleansing purposes is very clean cut and obvious. Perhaps you can adapt this idea to your own particular situation; it will bring results.

GAS men looking for a commercial load building item may do well to seek information on the gas heated continuous toaster used by the lunch rooms, restaurants and drug-store grills. Most of these toasters are sold with an electric heating element, but we note with glee that one big chain drug store which we visit now and then has turned to GAS. When asked the reason the man behind the counter said: "Well GAS is cheaper and too, it's *faster* and we have to toast 'em fast at noon—that's when folks demand quick service." You may take it from me, this particular chain keeps the gas on those toasters at least sixteen hours each day—figure it out; there's a nice piece of business that facts and figures will turn for you. Remember to tell these toast dispensers that GAS is FAST.

WHEN an electric man admits that electric cookery has not caught the popular fancy the way some folks strive to have us believe it has, we rejoice. Not so long ago a New York electric man is reported as saying that the big drawback to the sale of electric ranges may be attributable to first, the cost of the range, second to the cost of operation (think of that!) and third, the cost of installation. In another interview an electric man is quoted as saying that folks are prejudiced against the electric range by the fact that electric cooking takes up too much of their time. In other words, any thinking cook knows that GAS is the fastest cooking fuel

known to man, and too, home managers appreciate that it is controllable.

THE Laclede Gas Light Company, St. Louis, have been putting a bit of a much needed thing into their advertisements here of late. They blend

It's a
Great Game
Excitement . . . thrills . . . home runs . . . strikeouts . . . ninth-inning rallies . . . that's what makes baseball the great American game. That's what gives it such a universal appeal. You may sit in the stands, but mentally you're in every play, and when the game is over you are almost as tired as if you'd been in the lineup.
How do the players stand the strain of a pennant grind? Well, for one thing, after the game hot water washes away grime and fatigue and soothes tired nerves. To do your best in baseball or any other business, you've got to keep fit, and there's nothing more relaxing to a tired body or soothing to frayed nerves than a hot bath. With an automatic gas water heater there's always plenty of hot water whenever you turn the faucet. Ask about the new low-priced heaters at your plumber's or The Laclede Gas Light Company. Prices are lowest in many years and small monthly payments can be arranged.

a bit of humor with a bunch of human interest and thereby make a readable advertisement.

A GAS company in the middle west recently got a good play on their GAS Water Heater advertisement by tieing in on a city wide "Clean-up Week" sponsored by the Junior Chamber of Commerce. The GAS company's advertisements featured GAS Automatic Hot Water service as an aid to home cleaning.

THEY say that there is a new lamp on the market, called the black lamp or light, that is a very effective unit for use in displaying merchandise in a spot and that the rays from this new lamp bring out true colors. This is passed on as an item of interest to display men. Full particulars as to manner of installing, burning hours and costs of lamps may be secured from the local agents of the two big lamp manufacturers.

WE wonder how the gas man who sells electric washers justifies his efforts when he reads some of the current comments of our contemporaries on the subject of gas cookery. Those editorials give vent to, we'd say a lot of pent-up jealousy and we hope gas men will use no such insidious advertising. This is not necessary — Home Managers realize that GAS is the ideal, quick, clean, economical, safe, controllable fuel.

JUNE the month of brides and "sweet girl graduates" is at hand. Where is that gas man who is not thinking of window displays to attract these potential purchasers of GAS ranges, water heaters, refrigerators? Where is there a window display advertising man who has not laid plans to say to those home - managers - to - be; "Here is the place to view the rapid advances made by the manufacturers of GAS appliances, that you will demand for your home. Come in and let us explain just how wonderful they are." Where is that that writer of GAS appliance advertising who has not mapped out a plan to write reams and reams of selling copy, with appeals that will help the housewives of tomorrow to choose her home appliances wisely?

SEVERAL gas companies in Southern Illinois are promoting modern gas ranges in a rather novel manner. These companies are mail-

ing a letter to a select list of prospects offering a new cook book free of cost to those interested enough to return a paid return mailing card enclosed. When the card is returned a salesman delivers the cook book and also asks permission to demonstrate a new burner with which the new ranges are equipped. Safe to say this permission is usually granted and in many cases, as reports go, sales are made. It is also said that even where sales are not made, a great deal of interest is aroused and much is done in the way of impressing the consumer with the fact that gas is the most flexible, controllable fuel. In other words, these GAS men are not only selling GAS ranges of a new vintage but they are solidifying the fact that GAS cookery is least expensive, and most desirable in all respects. There is an idea to mull over.

THE New York & Queens Gas Company have a happy idea, when it comes to enploying small space for newspaper advertising. "No Rust for the Wary" is the eye-arrester for a hot water service advertisement that gets over a big sales story in two

No Rust
for the Wary
Do not despair if rusty reddish tinges tint the hot water so vitally important to your household these summer days. Here are words of cheer. We can show you the remedy. An approved storage type of gas water heater with a copper tank will give you quantities of hot water — automatically. As clear as the Danube is blue. And prices have never been more reasonable. Complete information is yours for the asking.
NEW YORK & QUEENS GAS COMPANY
136-21 Roosevelt Ave., Flushing, L.I. FLushing 9-5200

columns by three inches. Study this advertisement—it holds ideas.

RECENT round table talks have further indicated that our theory that the high-pressure salesman has had his inning is the opinion of the man who directs sales activities in many industries. At the particular lunch table we have in mind this opinion was voiced by the president of a chain store organization, the general manager of a roofing and building paper manufacturing concern, the sales manager of a paint and varnish manufacturing company and the secretary of the Chamber of Commerce. Selling, these men believe, in the future will be predicated on "service to be derived by the purchaser, and merchandise value. This will obviously require a knowledge of men and goods.

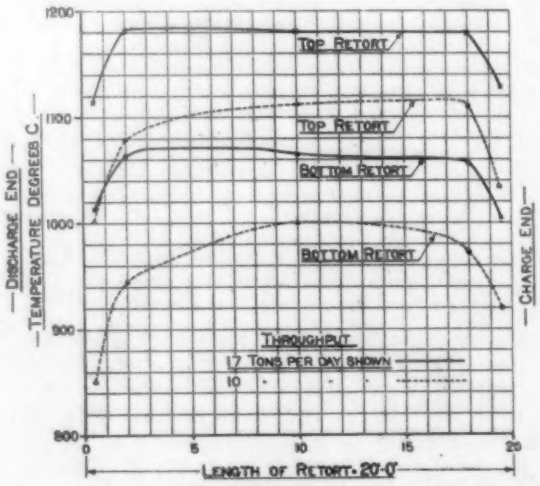
Technical Digest

FUEL AND GAS RESEARCH

Many interesting reports are included in the latest official publication of the Fuel Research Board in England. The physical and chemical character of the national coal resources of the country receives general consideration, while detailed reports are included on the methods of examining coal, including the constitution of coal, the determination of arsenic in coal and coke, the analysis of coal ash, the fusion temperature of coal ash, the use of selenium as catalyst in the determination of nitrogen by the Kjedahl method and the accuracy of analysis of coal and coke. In the case of the determination of nitrogen, the addition of selenium shortens the time by 45 minutes for coal and by about 30 minutes for coke.

The purification of coal is also discussed and reports are made on various systems, such as the Elmore vacuum flotation plant and improvements in the design of slurry settling tanks. One design contains inclined baffles, the effect of which is studied in considerable detail. The baffles reduce the proportion of solids in the outflow water to a considerable extent.

Carbonization and gasification of coal also receive considerable attention, particularly certain experiments on horizontal gas retorts and on the production of water gas. A new design, intended for increasing the rate of carbonization of coal and flexibility of the setting, is described. The physical basis of the increased rate of heat transfer from the gases to the coal was investigated and it was shown that the increase in volume of the flue gases at 15 degrees C from 27,400 to 76,070 cubic feet per hour (corresponding to an increase in the velocity past the retorts from 1.5 to 4.6 feet per second) resulted in an improved temperature distribution in the setting, and that the resulting rise in temperature of the outside of the retort walls is sufficient to account for the reduced time to carbonize a given charge of coal. At ten tons throughout there was a considerable difference between the external temperature of the center of the retorts and that near the ends. The increase of volume and velocity of the heating gases has the effect of increasing the temperature of the ends more than that of the center, so that not only does the mean external temperature of the retort rise, but the temperature from end to end becomes more uniform. This is shown graphically in the accompanying illustration.



Surface Temperature Explorations of a Top and Bottom Retort.

Hydrogenation of tar receives considerable attention, various methods of complete and partial hydrogenation being described. The use of pulverized fuel is also discussed and various miscellaneous topics, such as the use of coke for domestic heating.

SOFTENING OF COAL ON HEATING

According to a new method for studying the softening and carbonization of coal with the aid of the microscope, three grams of coal, size half to one millimeter, are heated in a current of carbon dioxide for 45 minutes to a definite temperature and held at this temperature until no more tar fog is developed. The coal sample is held in a tube which is rotated constantly at 30 R.P.M. to prevent the granules from caking together. The product obtained in this manner is encased in resin, the surface is ground and polished and then tested under the microscope. The bituminous coal granules become rounded off at a certain temperature and large pieces fall apart. When the temperature is raised, gas is developed and thin-walled hollow spheres are formed. As the temperature increases further, some of the spheres flow together to give hollow conglomerates and finally the walls become hard and porous. When visible plant residues are contained in the homogeneous coal mass, only the former melt and spheres with internal division walls are formed. Older (more carbonized coals) first become porous on melting, then harden with evolution of gas and finally soften. The older the coal, the higher the melting point. Rapid heating increases the fluidity of the mass and lowers the temperature at which fluidity takes place. Sufficiently carbonized coal gives only gas and does not melt. When a well-coking coal is heated to an oxidation temperature from 150 degrees C up for half an hour in a stream of air, artificially oxidized coal is made. This was treated in the same manner as described above. The higher the temperature, the more the softening point rises and the more the evolution of gas is accelerated, which means that the more the characteristic behavior of old coal is approached. The volatile products escaping from the coal sample during the carbon dioxide treatment may be used for the determination of the yield of low temperature tar.—*H. A. J. Pieters and H. Koopmans. Het Gas, volume 52, pages 478 to 482.*

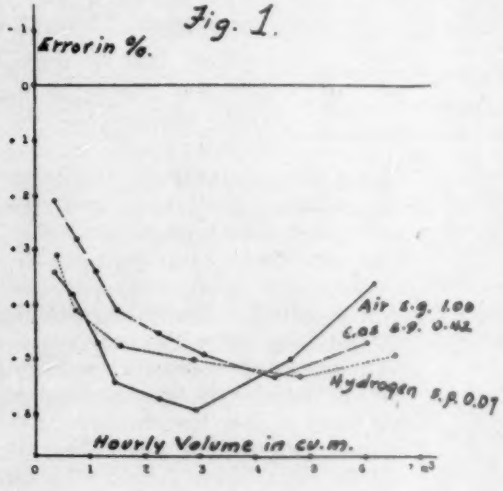
WATER GAS IN COKE OVENS

Important advantages are gained by producing water gas in coke ovens. These are particularly the production of a gas rich in hydrogen, an increase in the yield of gas and improved regulation of the thermal value of the gas. It is a

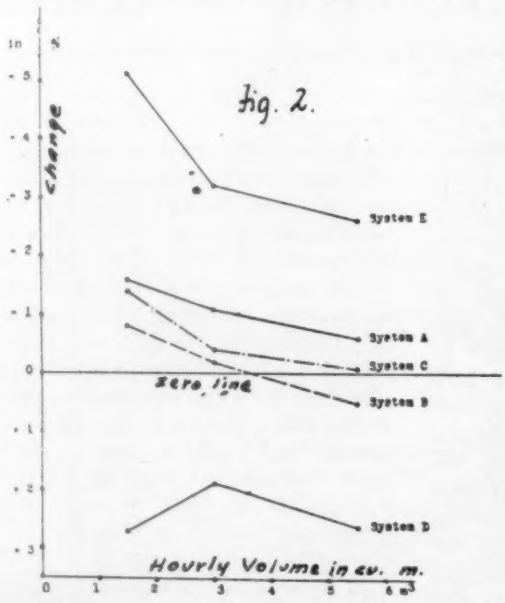
simple matter to install steam pipes in the ovens. Three different systems may be used in existing coke ovens. Two adjoining chambers may be connected by a pipe so that steam is introduced in one of the chambers and the water gas is drawn off from the other. Another system uses pipes perforated at the bottom which are introduced into the coking material. In a third system steam is blown in by means of nozzles inserted through the charging doors in the direction away from the ascension pipe. The last method permits the carburation of the gas to meet the demand of peak loads, which is accomplished by blowing in tar oils together with the steam.—*Gerhard Lorenzen. Stahl und Eisen, volume 53, 1933, pages 33 to 40.*

TESTS ON LARGE GAS METERS

A long series of experiments were carried out in several different makes of gas meters for metering a large quantity of gas, as used in Switzerland. The results are interesting only to the Swiss gas industry but certain complimentary tests were made which interest all who are concerned with gas distribution. One of such series of tests was concerned with the effect of density of the gas on the accuracy of the meter.



Experiments were made with air, gas and hydrogen. Thus, in the case of one type of meter, the error in measurement is shown in figure 1 for the aforementioned gases. Pressure losses, due to the friction caused by the mechanical operation of the parts of the meter on the one hand and on the other hand varying with the throughput of gas and the density, that is, the internal friction of the gas, do not have any appreciable influence on the accuracy of the measurement. The elasticity of the leather used in making the bellows was also studied. Just as the loss of pressure increases with the density of the gas, the volume of gas measured increases likewise with the dilation of the bellows, hence with the elasticity of the leather. It is this property of the leather which explains varying accuracy of meters.



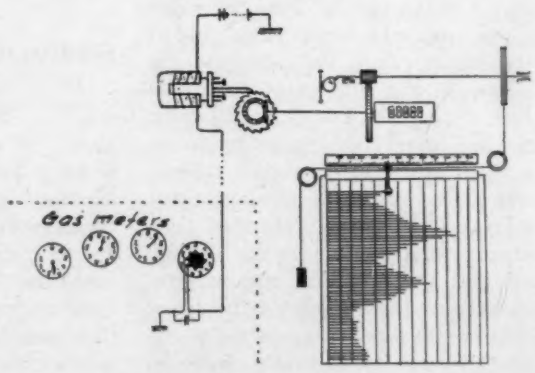
The rapidity of the shrinkage of the leather is also a function of the elasticity. Experiments were made with gas rich in benzene. It was established that the presence of hydrocarbons in the gas is the main reason for the shrinking of the leather. The use of various impregnating oils was also tested. The absorption of benzol constituents of the gas by these oils is responsible for the increase in the volume of the temperature on the accuracy of oils, but the absorption is not rapid enough to be controllable by the analysis of the gas. The effect of measurement was also studied. Two meters of each design were tested at 21 to 22 degrees C and also at 6 to 8 degrees C, which represents the extremes of temperature encountered in practice. The changes which are brought about by cooling the gas are shown graphically in figure 2.—*Bulletin Mensuel Societe Suisse del'Industrie du Gas et des Eaux, volume 13, 1933, pages 32 to 46.*

LONG DISTANCE STREET GAS LEAK

While the leak was first noticed in the cellar by a complaining customer, it was located actually at some distance from the house. Strongest odor was detected at the top of a dismantled lamp post. In barring over the main a pneumatic rotary drill was used to start a hole through the paving and when the drill had gone far enough, a solid pointed bar was driven through the dirt alongside the main to the approximate depth thereof. A smell pipe was then inserted in this hole, this being a five-eights pipe 5.5 feet long with one rounded nose end. This end was perforated for a distance of six inches with quarter inch holes. The perforated end is inserted into the bar hole, and by examining each bar hole carefully with the smell pipe a decision was finally reached at which opening in the bar pipe the odor was strongest and the break in the main was thus located. *R. C. Holcombe. The Philadelphia Gas Works News, March, 1933, page 10.*

LOAD REGISTERING INSTRUMENT

The instrument is actuated from the main gas holder or from station holders. The load curve is recorded on a traveling paper roll accord-



ing to the method commonly used in power plants. The instrument is connected electrically with the actuating device and hence it can be located at any suitable part of the works. The current used for this instrument may be of high or low voltage, according to what is available. Only one registering device is required for a number of meters or actuating devices, and in such cases the registering instrument can be connected to one or the other by means of switches. The meter at the main holder or the station holder is therefore read accurately in the control room of the gas works with ease and accuracy.—*Gustav Becker. Das Gas und Wasserfach, volume 76, 1933, page 114.*

Notes on High Pressure Gas Distribution

(Continued from page 10)

done whenever there is a drop of pressure during the lock-up test. If trouble has been experienced with porous diaphragms, it is also advisable at this time to place a soap bubble over the vent outlet, the breakage of which bubble would be an indication of such leakage.

The duration of the lock-up test depends on the make of governor, since it will be found that in certain types, especially those with a low lever arm ratio, there may be a slow build-up of the lock-up pressure after the initial seating has taken place. This usually is due to double seating, and eventually the pressure will remain constant. The rider on the U-gauge should be observed from time to time and changed to the higher reading so that the point at which the increase stops will be known, since frequently, once the maximum has been reached, the pressure tends to drop. In governors with these characteristics it is impossible to establish a maximum and minimum lock-up pressure which would be acceptable due to the build up, but a maximum pressure more than two inches below that at which blowing would occur should not be allowed. The lock-up pressure immediately after closing the outlet valve must be used under these conditions as a criterion for operating results, since it will be found that after being in service for a short time the indentation in the disc becomes more pronounced and the lock-up pressure lower and more definite. Often it is necessary to keep the governor on the lock-up test for twenty minutes or more during which time the repairman is assembling another governor or is provided with a second test block. Other reasons for slow build up are eccentricity and angularity between disc and orifice, porous or defective discs and defective orifice seats. Five minutes should be the minimum time for a lock-up test.

When a set screw for the purpose of adjusting the valve is part of the valve hinge, securing the proper lock-up is difficult, as there must be a balance between the compression of the spring above the diaphragm and the setting of the set screw. In this type of governor it is desirable to make a flow test, since the turning of the set screw to provide a proper lock-up may change the distance between valve hinge and orifice face to such an extent that the capacity of the governor is seriously interfered with. If this flow test is made with air, proper corrections must be applied to the flow results to offset the difference in gravity between air and gas. Air should be used where possible as a protection to the workmen. Most companies are discarding the governors incorporating a set screw in the valve hinge due to the difficulties encountered when repairing and adjusting.

A rapid increase in lock-up pressure which results in blowing can usually be traced to the disc, but it may be caused by the seat of the orifice being injured during assembly, incorrect assembling of the valve, a diaphragm stretched too tightly, a plugged breather hole, or such an uncommon cause as a shipping pin being in place.

The acceptable lock-up should be the same as that allowed the manufacturer on a new governor, since the reassembled job should be fully equivalent. On desired lock-up pressures between four and one-half to six inches of water column a variation from the selected pressure of more than three-tenths of an inch above or below should be the occasion for re-examination of the governor. On dead weight types, when the lock-up deviates from acceptable limits, the repairman should not remove or add weights. If the lock-up is within the allowable limits the governor should be returned to service without weight changes, as it will often be found, after a short period in service, the governor will gradually acquire the standard lock-up pressure due to the better seating between orifice and disc, unless it is affected by foreign material. When lock-up pressure depends on spring compression the repairman should familiarize himself with the average amount of compression necessary judged by the distance the pressure adjusting screw projects above the casting; any deviation from this would be the occasion for re-examination.

When particularly hard material or a facing is used on the disc the variation in lock-up pressure is greater and the limits may have to be raised to one-half inch of water column above or below that desired.

It has been mentioned that the lock-up pressure after reaching a maximum point may reverse itself and a slight drop will be noted. This condition does not warrant the time necessary for determining its exact cause if the tests for leakage have been thorough.

Immediately after finishing the test, shipping pins or blocks should be placed when required, the mercury removed, and the inlet, outlet and vent connections plugged.

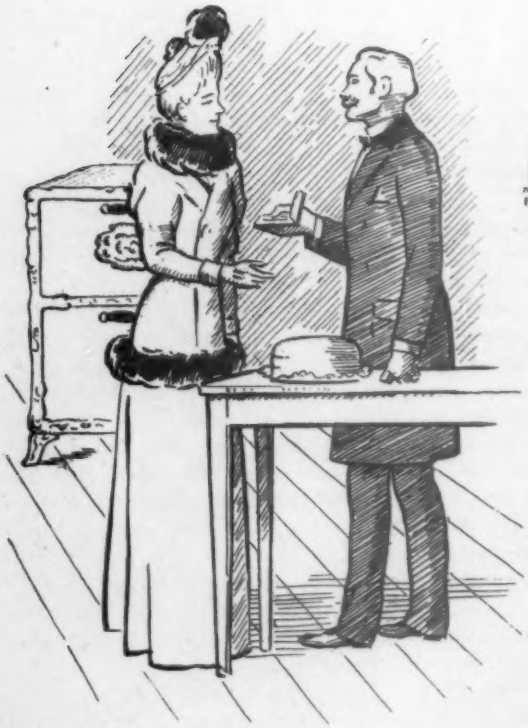
Painting Governors

The painting of governors may be made the function of the meter repair shop, with economic results, since that shop would be better equipped on a production basis. Where a separate shop is maintained, it is seldom advantageous to use any method but that of hand painting, as the number repaired per man per day does not warrant the time of setting up and cleaning trays or dipping tanks.

The size of shop necessary is determined entirely by local conditions and policies. As mentioned, it is unnecessary to remove governors from service periodically for inspections as is the case with meters. Repair of five to six governors per nine hour day covering all necessary types of work is the usual production per man. There are no territories using strictly high pressure distribution where the conditioning of governors is the only function of a repair shop, so that it is usually made part of the routine of either meter or tool repair shop.

Can You REMEMBER When-?

by E. Eisfeller



The Providence (R.I.) Gas Company will connect up the East Providence district by means of a continuous pipe under the Seekonk river, the diameter of the carrier to be 16-inch. At the present time the supply is maintained through a main over what is known as Washington birdge, feeding into a holder on Mauran avenue in East Providence, but the interruption in the supply, because of the opening of the draw, together with the greatly increased demand for gas in the east section of the city, determined the Company to go to the expense of settling the matter permanently. Mr. Joseph G. Falcon, of Evanston, Ills., is the contractor. The expense of the undertaking is put at $21,000.—*American Gas Light Journal, May 22, 1899.*

Some time ago we noted that the proprietors of the Bowling Green (Ky.) Gas Light Company had offered for competition a gold watch, to be awarded to the housekeeper who should, within a specified time, have sent to the Company the best specimen of a white cake, home made, and baked in a gas heated oven. It is not necessary to here repeat the conditions of the contest. Suffice it to say that the contestants numbered a bakers' dozen, and the jury awarded the prize to Mrs. John Carter, wife of a well-known engineer on the Louisville & Nashville Railroad. It is worthy of note that the prize winner had only an experience covering four months in the use or manipulation of a gas range. — *American Gas Light Journal, May 16, 1892.*

The street gamins of New Albany, Ind., have been amusing themselves so greatly of late in smashing the glasses of the gas lamps in that city that Superintendent Dunbar has been obliged to offer a reward that will lead to the conviction of any of the offenders.—*American Gas Light Journal, April 14, 1890*

Review of GAS RANGE COMMITTEE'S MARKET ANALYSIS and RESEARCH

By JOHN A. FREY

Vice-President,
Detroit Michigan Stove Company

IT is only logical to want to know something, first, about the size, location and intensity of our domestic gas market. Therefore, to find this out, we dug into the most current records of domestic meters for both manufactured and natural gas, and plotted on large state and county maps, in various colors and in figures, the distribution of domestic gas meters by actual count. We were amazed, indeed, after figuring for weeks, and then plotting these figures on maps, to discover that 84.4% of our entire domestic meter population is located in only 224 out of the total of 3072 counties in the United States.

Meter Concentration

We discovered further that 81% of our total meters are located in only 13 states. 10 of these states are east of the Mississippi and north of the Mason-Dixon line, the other three being Missouri, Texas and California. Being able to so locate and plot our market has a definite bearing on our merchandising policies, as it permits us to concentrate our efforts in those areas where the greatest proportion of our market is located. It lets us effect economies by reaching this market in the most direct, effective and economical way. It permits us to choose ways and means which will cost us less per meter coverage than if we endeavored to conduct a broad, blind merchandising program not supported by this market information.

As a general conclusion of these studies, we were able to segregate our entire market into the two general classifications. First, a primary market in which are located 420 cities, representing 80% of our total gas consuming public, and next, a secondary market in which are located 7,656 towns and villages representing 20% of our gas consuming public. By these figures we have been guided in our planning and have arranged our activity to concentrate our greatest merchandising effort in the 80% of our market—yet also employ other methods that will cover the remaining 20% completely and thoroughly, without running up our cost proportionately. Now don't think for one moment that those 7,656 cities and towns located in the 20% of our market will be slighted. In fact, they will receive just as effective and thorough coverage as does the 80%—we merely employ different methods to reach them.

Equipment Survey

After thoroughly analyzing our market and discovering exactly where it rests, the next job was to analyze from a different standpoint to learn what kind of equipment is in use. This information will determine to a great degree our campaign style, and also what we should talk about to stimulate the greatest return from our market; in other words, our campaign theme.

As a result of these studies, we found that of the 15,850,000 gas ranges in use, over 12,000,000 of them are of an old, obsolete type with none of the modern conveniences that exist on the gas range of today. We discovered, for example, in a general average, that: *8% of the domestic gas ranges in use today are less than one year old . . .*

. . . that 6% are from one to 2 years old

. . . that 8% are from 2 to 3 years old

. . . that 10% are from 3 to 4 years old

. . . that 68% are over 4 years old.

Isn't it amazing to learn that 78% of the total gas ranges in use today are more than 3 years old, especially in view of the many developments that have been made in gas ranges in the last 3 years?

Reason for Concern

Is it any wonder, when this condition exists, that the gas industry should be concerned about its future growth and the growth of competition? Is it not true that we are wide open and inviting the intrusion into our market of any competitive cooking equipment and fuel? When you stop to consider that more than ¾ of the cooking units in existence today are of an old-style, obsolete type, any far-sighted executive in the industry should certainly be deeply concerned, because in this fact rests the reason for our present danger. The correction of this serious condition is the one end we should *all strive for* with the greatest expediency. I assure you it is certainly the prime objective of this committee and our campaign planning.

The next step after discovering the deplorable condition of the equipment being used today was a thorough study of competition to determine, first, who they are; second, the methods they are pursuing; third, their past activities in merchandising; and, most important, their plans for the future. We naturally questioned seriously the ethics of their movements in some respects—the means they are using

Portion of an address, "Development, Research and Advertising—The Manufacturers' Contribution to the Industry—As It Affects Sales," delivered before Meeting of Southern Gas Assn., Washington, D. C., May 3rd, 1933.

ostensibly to convince the American public of the superior qualities of their fuel. Now, first of all, let's not be misguided or biased in actually sizing up competition. We should thoroughly understand their strength and their weaknesses if we are to deal with them successfully. Consequently, this committee took a perfectly unprejudiced, neutral view of the entire situation. We analyzed very thoroughly their practices and their methods and their plans. We also very thoroughly compared the two products, to determine the true condition of affairs.

I am not privileged to take the time to give you the results of these findings, but I do wish to warn you that you cannot minimize some of the qualities which they have to sell. However, I do want to say that *if* we are successful in re-establishing, through this campaign, an unquestionable recognition for the many superior qualities and advantages of the new-type modern gas range, we need not fear the movements of competition. It is very easy to understand why they have taken those points which are definitely their weaknesses and have, through aggressive merchandising, been partially sucessful in convincing the American public that these weaknesses are actually their strength.

We Are To Blame

We discovered in the course of extensive field studies that the electric industry *has had a measured degree of success in this direction.* We have visited many homes in various sections of the country and, with a few simple questions, have found the attitude of the American housewife toward electric cookery and what she knows about the modern gas range. I will not take the time to elaborate on this point other than to say that the results caused this committee to act with renewed vigor and enthusiasm to complete our market analysis and research work so that we might start the development necessary to correct a very dangerous situation. We have no one to blame for this condition but ourselves. We have not, in the major number of cases, proceeded along the right lines to get the greatest benefit and return from what merchandising we have done.

The need for new and more productive merchandising practices on the part of the gas industry to overcome certain conditions that *do exist* is becoming more acute every day. We must merchandise the many conveniences and superior qualities of gas as a cooking fuel and we must make known to the women of America the many new features and improvements and conveniences of the new-type modern gas range of today. We must firmly establish the modern gas range as the most modern means of cooking. Is it any wonder that a woman is definitely captured by the glamor of our competitors' story when in 9 cases out of 10 she has an old-style, obsolete gas range in her kitchen to compare with the modern electric range? Women in general do not know what has happened to the gas ranges in the last four or five years. It is lack of understanding that is responsible for the condition of our market today, and for the growth of competition.

Lacking in Advertising

Yes, we might say we have advertised . . . but we have not—in the opinion of this committee—advertised extensively enough or *correctly.*

Another interesting phase of our study of electric competition was our analysis of their price structure. (It is standard practice among almost all national distributors for the cost of merchandising to be considered in the same manner as the cost of any material used in production—it is written into the price.)

In analyzing the price structure of the leading electric range manufacturers, we find that the allowance therein for merchandising is sufficient to permit them aggressively to get behind their products and cultivate an acceptance for them. General Electric and Westinghouse—with a combined range production not equalling that of one of our average-size gas range manufacturers—through the addition of a sufficient margin for merchandising in their prices, have been able to do more national advertising of electric cookery than the entire gas industry did last year. Think of this! It is an astounding and deplorable situation. When you buy a can of beans, a tube of tooth-paste, a refrigerator, or an automobile, you have paid the cost of merchandising that product to you. The gas industry cannot be expected to merchandise adequately so long as we continue to practice the antiquated and destructive methods now popular in relation to the wholesale and retail price of equipment. Truly, it is the fault of everyone alike, but we must change our attitude toward price if we have any regard for the future of our industry.

While I am on the matter of price, let me relate to you the results of a survey which was made among nearly all the good dealers in this country—2317 of our largest and best stores. We asked these dealers some very pertinent questions in relation to certain specific phases of our program, and two of the questions dealt exclusively with price. When asked what effect they thought a very slight increase in consumer price would have on gas range sales, out of the total of 2317—88% of these dealers said that to increase prices would have no effect on sales. But nearly 40% of the 88% stated specifically that to raise gas range prices *would increase sales.* In addition, these 2317 key dealers were asked if they would object to manufacturers raising prices still further to permit them to merchandise their products individually. 79% of the total agreed that this would be not only permissible but advisable.

Aid Needed by Dealer

Dealers realize that the trouble with the gas range business today is that there is not nearly enough aggressive merchandising to assist them in moving equipment from their floors. And, being familiar with the practices of other industries in helping them sell, these dealers know full well they are being deprived of a sales volume of higher priced equipment which would normally be created by the industry's own merchandising efforts. If this committee is successful in our campaign, we plan to correct this situation by urging all manufacturers to do more consumer advertising in addition to that included in our plan. Under no condition are we asking any manufacturers in our group to sacrifice or curtail their own individual advertising—nor would we permit them to—in behalf of our campaign. Both are needed badly.

But to get back to the dealer: another important question was asked

to determine whether or not it would be possible to bring about a highly cooperative condition among all dealers and utilities selling gas appliances. The question was asked: "To what extent will you be willing to cooperate with other gas range dealers in your city to make this campaign a success?" Ninety-eight per cent stated that they would cooperate fully. This particular question has a definite bearing on our campaign plans because we have prepared a very extensive plan dwelling specifically upon the cooperation of dealers and utilities. The importance and necessity for dealers and utilities to work hand in hand must be recognized. I have briefly outlined the importance of the utilities merchandising appliances and it is through the organization and operation of gas appliance societies in all our markets that utilities will, to the increased satisfaction of dealers, become more active in their own and in dealers' merchandising practices. This Local Society plan will place all utilities in a stronger and more secure position with dealers. It will increase the sales of fully automatic equipment and it will definitely check at the source, the growth of electric cookery. I cannot dwell much longer on the function of these societies. However, I would like to bring one phase to light that pertains to selling methods and sales practices of the industry.

Furthering Aggressive Selling

Through these societies will be taught new aggressive and productive sales methods that will not only develop more prospects but will put over in every solicitation an *appealing and convincing story of gas cookery*. In selling other commodities, dealers receive specific sales assistance coordinated very closely with well-directed advertising, so that after a demand is created and prospects come into a dealer's store, he is equipped with sufficient sales ammunition to close the greatest number of prospects. The gas industry is seriously lacking along these lines. I think we all realize this and will welcome an abrupt change for the better, for we all realize that through the present fallacious sales practices we are again leaving the way clear for the progress of electric cookery.

A study has been in progress for many months, among 1500 leading department stores located in important shopping centers throughout the country, to determine the price trends of gas range purchases by three price classifications: low, medium, and high. So far, this has disclosed some very interesting information and conclusively proved a point—that is: the sale of the higher-price class of merchandise—from $75 on up—is growing rapidly. However, there is a variation among some stores in relation to this particular point. While the majority of stores do sell in greater volume a higher-price class of merchandise—that is, fully equipped—there are a number who tore down our average seriously. In checking back among these institutions, it was found that the stores having a greater sales volume of high-priced merchandise are those stores that are selling gas ranges on the basis of convenience, beauty of design, economy of operation, and the many time-saving qualities of the modern gas range, while the stores selling strictly on a price basis are moving practically only the lowest priced equipment. This has been proved true in case after case over the country.

Women Want Modernity

Women today want fully automatic gas ranges. They want to buy convenience and time-saving qualities that will lighten their burden of cooking. But when the matter of price is constantly driven before them and the sale is made on this basis, naturally the merchandise that moves most readily is that which sells at the lowest figure. This is a very unhealthy condition, because a stripped, cheap gas range is a perfect target for electric cookery salesmen. And the purchaser still remains one of the 12,000,000 families in the United States which are today our cause for great concern.

We should all be fully cognizant of the importance of our endeavoring always to sell fully automatic equipment. Needless to say, we must protect our cooking load by replacing old or stripped gas ranges with new, fully-automatic ones. When you stop to realize that ¾ of the cooking load of the industry is wide open, inviting the growth of electric cookery because of the old-style obsolete equipment in use, you must realize that *the condition is not safe*. A satisfied user of a new-type modern gas range cannot be considered a prospect for an electric range. Therefore,—remember this point—the rapidity with which we remove from our lines those old-style gas ranges will determine to a great degree the extent of the growth of electric cookery.

Study of Sales Potentials

The last phase of the various market studies and research which were made, pertained to the sales potentials today for gas ranges and hot water heaters. Through a multiple correlation method—a method in use by large merchandisers today—an exhaustive study was made to determine the sales possibilities for gas ranges and hot water heaters in every city and town in the United States. This involved a terrific amount of work but the results which we have obtained well justify the time and effort put into it. We know the individual sales potentials for each market center in the country so that now this committee is equipped to go into these markets and spend there an amount of money in direct proportion to the possible sales return of that market. These studies were made in order to guide us in those areas of the greatest sales possibilities and also to permit strict economies to be effected in all territories, so that no money would be wasted. Any utility in the country is privileged to know the sales potential for gas ranges and hot water heaters in his area if he wishes, and a letter to me will bring this information.

The committee was organized a year and a half ago with the express purpose of digging into the gas industry and bringing to light our methods and practices, and all the other factual information needed in order that we might approach our common problem with the greatest effectiveness and accomplish our ends with the greatest expediency. Now, after a year and a half of intensive study, we are ready as manufacturers to make our contribution to the gas industry and to effect sales. After all this work, you have a perfect right to ask—what really are our objectives? . . . What do we *really* propose to do? I am going to

enumerate what this committee and the manufacturers' group behind it are ready to do with the proper support from not only all manufacturers but likewise from all utility companies.

First, we must re-establish the modern gas range and gas cookery in the minds of American women as not only being modern, economical, fast and dependable, but clean, convenient, efficient and time-saving.

Second, we must create a new demand and a new volume of sales of fully automatic gas ranges by making known to all women the many automatic features and improvements that the new type modern gas range offers, thereby establishing the difference between the modern gas range and the old.

By the foregoing two objectives we will be definitely protecting the cooking load against the desperate efforts that competition is making to take this away from us, knowing—as they do—that the elimination of our cooking load is the elimination of the gas industry.

Third, we plan to establish new operating and sales practices between dealers and utilities that will make for sounder relations. Our objectives in this respect are to stop permanently any thought of protective legislation by dealers against utilities. It will also mean a greater turn-over in volume of fully automatic equipment. Dealers are willing and anxious to cooperate with other dealers and with utility companies. Our campaign includes a very elaborate cooperation plan to be carried on locally by utilities with dealers. This is one of the most important activities of our program.

Fourth, through various phases of this program and recommendations which we have ready for utility companies, we propose to strengthen and promote more favorable public relations in every community. A very thorough study has been made of this phase of our program and after we are under way we will graphically portray to each utility ways and means that will strengthen their position publicly and develop a renewed favorable acceptance for gas in the home.

These are the objectives that we plan to accomplish by this proposed merchandising program. We do not fail to recognize, however, several important points that must be carefully watched throughout this entire activity. Under no conditions is this committee endeavoring to run controversial advertising. We have found that to carry on this campaign with the greatest effectiveness is to stick exclusively to our task of selling the advantages of gas as a cooking fuel, and to do this without controversial or negative advertising we will with the greatest expediency accomplish the purposes of our campaign. We are not under any condition attempting to prove to the slightest degree that the merchandising efforts of electric cookery are wrong. We do not have to do this. We hold the upper hand and all we need to do to strengthen that position is to ignore the existence of electric cookery, sell aggressively our own wares by creating the desire to own a new type modern gas range in the minds of the greatest number of women.

Cooperation Necessary

To wave our arms and shout "wolf" and to cry for a broad national rebuttal against the electric industry would be disastrous. Our program is strictly a merchandising campaign on gas and the new type modern gas ranges and nothing else. Furthermore, the most successful and effective way to conduct this campaign is right in each local utility's own back yard.

I am not saying that we do not propose to use national advertising—we could not get along without it in our campaign. But I do want you all to fully understand that to accomplish the purposes of this campaign it must be executed in close cooperation with each utility in your own specific localities.

The peculiarities in the gas industry which make it different from other industries thereby not permitting us to accept standard practices of merchandising that are being successfully conducted in other lines of business could be made to be assets in the conduct of our work. In the first place, the two major producing elements of the industry have two distinct functions: the manufacturers, in addition to contributing to the entire industry with this proposed campaign, have a tremendously important duty to perform in constantly watching the trends of the times in order to improve and perfect the operating efficiency and performance and appearance of their products to keep them always superior to those products of competition and to have them conform to the modern trends of the times. This is one task.

The other major producing element in the industry—the utility companies—have an equally important task to perform: that is, to watch and guide the movements of distribution and capitalize to the fullest extent in cooperation with dealers upon the ever present demand for more modern equipment in the home. Gas is unquestionably the most modern fuel for cooking, refrigeration and heating. Therefore, your intimate contact with dealers and the public puts you in a position of advantage to strengthen public relations constantly and to strengthen dealer relations constantly so that both of these powerful forces are pulling with the industry to the ends that we constantly increase the demands for more modern equipment. This gives both the utility and the manufacturer an equally important part to play and each must be vitally interested in the other's duties.

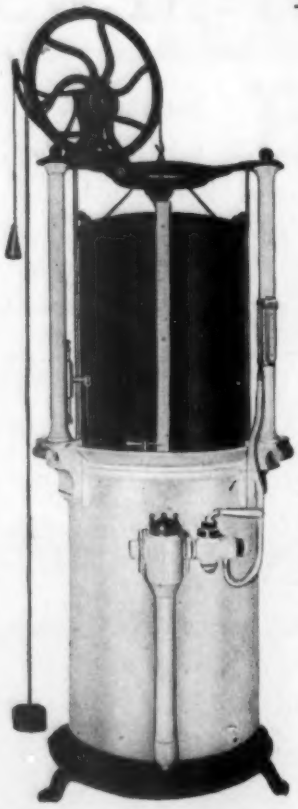
Every manufacturer should be constantly thinking and doing those things which will assist the utilities in developing and improving public relations and dealer relations because without either of these the manufacturers are affected in exactly the same proportion as are utilities. Vice-versa, utilities should watch carefully the trends of the time and the demands of the public and make sure that when ranges are sold either by dealers or themselves they are the latest, most modern, fully automatic types because failure in these respects has just as much of a bearing upon manufacturers as it has upon utility companies.

On the one end of our industry's operation are the manufacturers vested primarily with the responsibility of production; while on the other end stands the utility companies guiding the sales, distribution and public acceptance of our industry. In other words, each one of us represents the whole—we have the same purposes in view . . . we have the same problems. Consequently in the interests of all concerned, I ask in behalf of this committee that

(Continued on page 42)

SUPERIOR

Gas Meters
Provers
Service Cleaners
Diaphragms
Repairs



SUPERIOR METER CO.
167-41st Street
Brooklyn, N. Y.

Lux Material

Guaranteed to always run uniform. It has been used by Gasworks all over the world for over 50 years. We offer same from a shipping point most conveniently located to your works. Shipped in bulk or bags.

Lux-Sponge
THE PERFECT READY MIXED OXIDE

For Gasworks having no facilities to mix their own Sponge we offer our celebrated "Lux Sponge," guaranteed efficient for Coal or Water Gas.
Samples upon request.

Chicago, Ill. **THE ALPHA-LUX COMPANY, Inc.** Philadelphia, Pa.
192 FRONT STREET - NEW YORK CITY, N. Y.

ISBELL-PORTER COMPANY

Engineers and Contractors for Complete Gas Works

I-P C

Manufacturers of All Kinds of Gas Apparatus

NEWARK - NEW JERSEY

EQUIPMENT NEWS

New Robertshaw Combination Control

An ingenious combination oven control thermostat and oven gas valve has just been engineered and announced by the Robertshaw Thermostat Company of Youngwood, Pa. This new control unit contains a standard Model "F" Robertshaw "AutomatiCook" oven thermostat of the popular "dial" type.

The oven thermostat is surrounded by a chromium plate and the oven gas cock actuates below this plate, traveling from a point immediately below the plate—the "off" position—to the horizontal or "on" position. Both of these positions are clearly marked on the plate.

Robertshaw Combination Control

By grouping these controls together, an advantageous assembly is provided. The complete oven controls are brought together and the entire unit is installed on the manifold panel. This not only permits better range design, but aids the housewife since all of the range controls can now be assembled in the most convenient and visible location.

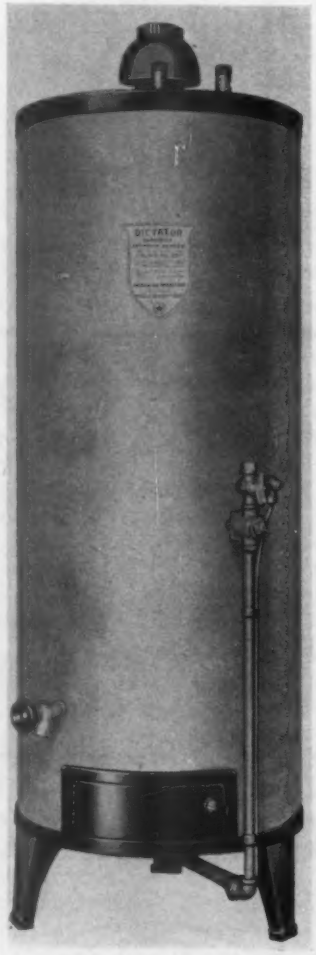
While the oven thermostat and gas valve are grouped together, their operation remains entirely independent of each other. Either control is instantly accessible for adjustment or regulation without disturbing the other unit.

By separating entirely the dial of the oven control and the handle of the gas valve, an important safety feature is afforded. It is instantly discernible, even from a distance, whether the gas valve is turned completely on or off. There is no danger that the operator, in turning the dial to secure the desired temperature setting, may unwittingly turn the gas supply off and on.

With gas range buyers keenly interested in automatic oven control these days, this new combination provides an important selling feature. It makes an interesting demonstration and helps create a great deal of added interest and desire for new range ownership.

The Dictator

American Gas Products Corp., 40 W. 40th St., New York, a division of the American Radiator Co., announce a new, low-priced gas-fired automatic storage water heater with many features never before combined in similarly priced heaters. This new heater is called "The Dictator." Some of its features are: heavy blanket of rock wool insulation on sides and top, heavy cast-iron base and legs, high lustre baked enamel jacket, heavy tank construction, snap action thermostat and bi-metallic thermostatic pilot.



The Dictator

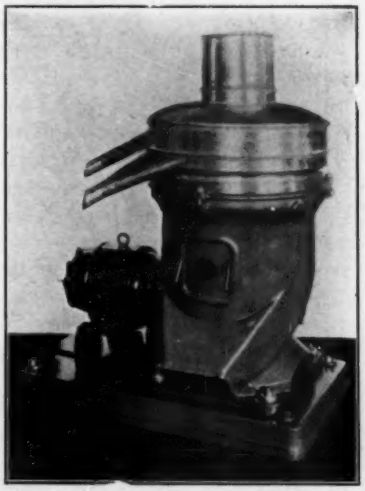
This new product supplements the A.G.P. Special water heaters to provide a complete line of automatic water heaters.

The Dictator is made in 15, 20, 30 and 40 gallon sizes.

The Sharples Rotojector Centrifugal

A NEW field for the application of high centrifugal force to clarification and separation problems is opened up with the recent introduction of the Sharples Rotojector Centrifugal, manufactured by the Sharples Specialty Co., Philadelphia, Pa.

The Rotojector Centrifugal combines high centrifugal force with the remarkable ability to discharge its solids or bowl cake while running at full speed.



This feature eliminates the labor heretofore required for bowl cleaning and permits the use of the Rotojector in places where excessive bowl cleaning would make the Super Centrifuge economically impractical.

It is particularly adapted to the clarification of liquids containing high percentages (up to 10 percent) of amorphous and slurry precipitates; the clarification of liquids where the labor cost of bowl cleaning is a serious item regardless of the equipment now used; the separation of liquids which contain large amounts of solids (up to 10 percent); the reclaiming of valuable liquids held in slurries; and the removal and recovery of valuable sludges without the labor of bowl cleaning

(Continued from page 40)

we unite in an actively designed program primarily to protect the cooking load of our industry.

We must re-establish the fact that the most modern means of cooking is the modern gas range. Our plans are sound, constructive and very well founded. We want to present them as the manufacturers conrtibution to the industry. Will you give your support and help to make them materialize?

All sizes up to 3,400 cu. ft. capacity

Meters
Diaphragms
Repairs
Provers
Pumps
Calorimeters
Wet Meters
Gauges
Apparatus

METER REPAIR PARTS

FOR

ALL MAKES - ALL SIZES OF METERS

LARGEST GAS COMPANIES NOW USING OUR PARTS

SEND FOR OUR CIRCULAR ON METER REPAIR PARTS

SAMPLES AND PRICES GLADLY SENT

— o —

LAMBERT METER CO.

BUSH TERM. BLDG. 4, BROOKLYN, N. Y.

feature
Unusually Comfortable Rooms
and the
Finest of Foods

In Cleveland it's ✠ The HOLLENDEN

In Chicago it's ✠ The LA SALLE

In Columbus it's ✠ The NEIL HOUSE

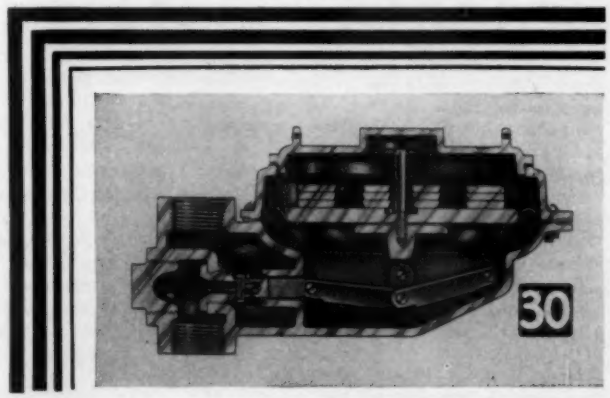
In Akron it's ✠ The MAYFLOWER

Rates from
$2.50 Single, $3.50 Double

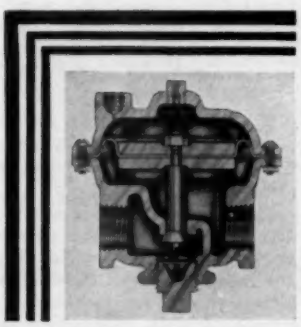
De Witt Operated Hotels
are Located in the
Heart of their Respective Cities

Reynolds Regulators

give more years of operating performance and get on the service cost sheet less than any other units on the market. But there is a reason for this—Reynolds policy of manufacture, their method of examining material and testing the completed regulators assures buyers that the units bought have a prior performance that ordinarily will not be duplicated in actual performance. The hundreds of thousands of Reynolds regulators giving satisfactory performance after years of service is substantiating proof of the ability of these regulators. Reynolds engineering department is glad to co-operate in working out and solving your gas control problems. Write.



Reynolds low pressure refrigeration regulator gives consistent delivery pressure for combustion purposes regardless of varying line pressures or uneven volumes. These units are built of quality material and factory tested through a range of possible operating conditions. The record of actual performance is assurance that they will operate over a period of years without maintenance service.



● **REYNOLDS BRANCH OFFICES:** 421 Dwight Building, Kansas City, Mo.; 2nd Unit, Santa Fe Building, Dallas, Tex.

● **REPRESENTATIVES:** Eastern Appliance Co., Boston, Mass. F. E. Newberry, Avon, N. J.

REYNOLDS GAS REGULATOR COMPANY
Anderson, Indiana, U. S. A.

GAS CONTROL SINCE 1892

Personals

T. P. Keller, formerly a chemical research engineer of the Cities Service Company and its subsidiaries, has recently joined the Gas Purifying Materials Co., Inc., according to a recent announcement by B. D. Klein, president.

Mr. Keller has been connected with the General Chemical Company as a research engineer on the development of catalysts and methods for the recovery of sulphur and organic sulphides from sulphur ores and smelter gases.

Later joining the Cities Service Company as research chemist, he studied and developed processes for the utilization of oil and natural gas. He is the author of several recent publications and patents, on products related to the gas industry. In recent years he has studied the mechanism of gum formation in natural gas.

As research chemist and supervisor of the manufacture of iron hydroxide for Gas Purifying Materials Co., Inc., the gas industry will be well served.

F. Christopher Weber has been appointed vice president in charge of engineering activities of The Brooklyn Union Gas Company.

Mr. Weber became associated with The Brooklyn Union Gas Company on September 1, 1927, as assistant vice president. Prior to this, he had been connected almost continuously with the Henry L. Doherty organization since his graduation in 1905 from Purdue University. From 1908 to 1912 he was associated with the Freeport (Illinois) Gas Co., first as superintendent, and then as secretary and general manager.

Mr. Weber, who was born in Cleveland, Ohio, is a member of the Board of Directors of the Brooklyn Chamber of Commerce and of the Board of Governors of the Crescent Athletic-Hamilton Club, a member of the Society of Gas Lighting, and for a number of years has been active in various committees of the American Gas Association, being a past chairman of its Technical Section.

B. G. Neilson has been appointed vice-president in charge of commercial activities of The Brooklyn Union Gas Company.

Mr. Neilson, who is a certified public accountant, joined the company as assistant vice president on May 1, 1929. Previously he had been secretary and treasurer of Bowring and Co., internationally known foreign merchants and steamship owners. He was in charge of that company's foreign department.

Mr. Neilson was born in Scotland. Immediately prior to his connection with Bowring and Co., he had been associate manager of a branch office of a well known public accountancy firm.

T. S. Lever recently resigned as manager of the Internal Audit Department of The Philadelphia Gas Works Company and was named controller. This is a newly created office, to which will be transferred all general accounting and commercial accounting, meter reading and collections.

Mr. Lever has been employed by the company for about 28 years, having held the positions of clerk, dispatching clerk, auditing clerk in the Records Division, chief clerk, and finally manager of Internal Audit Department, to which he was appointed in September, 1930.

Other changes made in the personnel of the company are:

G. A. Mead resigned as assistant treasurer and was appointed assistant controller. Mr. Mead has been in the company's employ for about 25 years, having been in the Treasurer's Department for all of that period. He rose to the position of assistant treasurer through the many positions in the department.

H. H. Hessler resigned as assistant manager of the Internal Audit Department of the Philadelphia Gas Works Company and was named manager of that department to succeed Mr. Lever.

W. G. Eager, formerly representative of the Stone and Webster Corporation in Georgia, has assumed management of the Valdosta Gas Company, at Valdosta, Ga., it has been announced. Mr. Eager, who is one of the best-known engineers in the South, succeeds F. M. Cahill in his position of manager of the Valdosta company, Mr. Cahill having been transferred to North Carolina.

Ed C. Pfenning, manager of the Joplin Gas Company, Joplin, Mo., recently was honored by being elected president of the Joplin Rotary Club for the Rotary year 1933 and 1934. This is quite a distinction and honor for Mr. Pfenning in view of the fact that there are some 125 prominent business men members in that city.

The office also carries with it the distinction of representation of the Joplin club at the International Club Convention to be held this year in Boston, Mass.

R. O. Berry, head of the new business department of the Savannah Gas Light Company, Savannah, Ga., has been appointed assistant treasurer of the company, it has been announced by President J. A. P. Crisfield. He will continue to act as head of the new business department, it is stated.

Before coming to Savannah, Mr. Berry was connected with the Anderson Gas Company, of Anderson, Ind., and also with the Jacksonville, Fla., Gas Company, where he was with the sales department.

C. R. Davis, who has been engineer with the Savannah Gas Light Company, Savannah, Ga., for the past six years, has been promoted to assistant manager, it has been announced by President Crisfield. He is a graduate of the University of Pennsylvania, and has been connected with the Savannah company for six years.

John D. Rigney of Jerome, Idaho succeeds J. M. Thompson, retiring as president of the Idaho Public Utilities Commission. **M. Reese Hattabaugh** of Grangeville and **Harry Holden** of Idaho Falls are the other members of the commission.

E. C. Uhlig, Chief Chemist and educational vice-president of The Brooklyn Union Gas Club, Brooklyn, N. Y., has been reappointed a member of the American Gas Association Committee on Education of Gas Company Employees. Mr. Uhlig has been a member of the committee for the past six years.

Convention Calendar

May

17-19 American Petroleum Institue, Mid-Year Meeting. Tulsa, Okla.

22-23 American Gas Association Joint Committee Conference of Production & Chemical Committees. Hotel New Yorker, New York, N. Y.

June

1-2 American Gas Association, Executive Conference. Chicago, Ill.

12-15 National Association of Purchasing Agents. Chicago, Ill.

22-23 Pacific Coast Gas Association, Northwest Regional Conference, Olymphic Hotel, Seattle Wash.

22-24 New York-New England Regional Sales Conference Griswold Hotel, New London, Conn.

26-28 Advertising Federation of America & Public Utilities Advertising Association. Grand Rapids, Mich.

26-30 American Society for Testing Materials. Chicago, Ill.

26-30 American Society of Mechanical Engineers. Chicago, Ill.

26-30 American Institute of Electrical Engineers. Chicago, Ill.

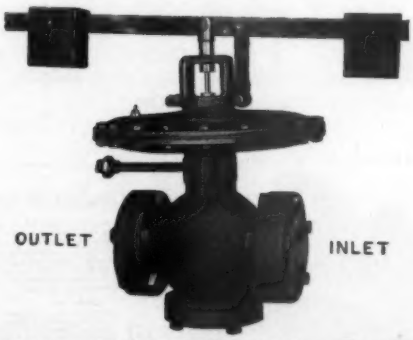
September

13-15 Pacific Coast Gas Association, Ambassador Hotel, Los Angeles, Calif.

18-19 Canadian Gas Association, annual convention. Ottawa, Can.

Week of September 25, Annual Convention of American Gas Association, Chicago, Ill.

Where Inlet Pressure Is Low



THE Fulton Weighted Illuminating Regulatór, designed for either natural or manufactured gas, will reduce from inlet pressure of 40 lbs. or less to any delivery pressure between one ounce and 5 lbs. No stuffing box, practically frictionless, highly sensitive, specially adapted for use where difference between inlet and outlet pressure is very slight. Ask for full information about this regulator or any requirement of pressure control.

The Chaplin-Fulton Mfg. Co.
28-40 Penn Avenue Pittsburgh, Pa.

FULTON
Weighted
Illuminating Regulator

CF

"USING CHACE BIMETAL on our oven temperature controls Since 1929"

THE HART MANUFACTURING COMPANY

Because of its accuracy, uniformity and complete dependability, many leading manufacturers have standardized on Chace Bimetal for the automatic operation of their products. Submit your problems to Chace.

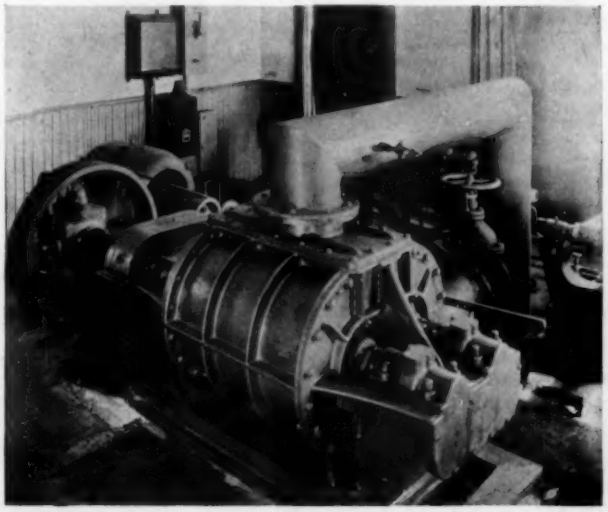
Sold in:

SHEETS
STRIPS
FORMS

CHACE THERMOSTATIC BIMETAL
"It Bends with the Heat"

W. M. CHACE VALVE CO.
1610 Beard Avenue

POWER VARIES WITH LOAD



ECONOMICAL OPERATION

POWER savings are possible with Rotary Positive Gas Pumps that are not inherent in other equipment, because the power required varies directly with changes in volume and pressure—an outstanding feature.

Full advantage is taken of these savings in the interesting installation illustrated herewith.

This R-C-W Gas Pump, installed at the Spokane Gas & Fuel Co., is driven by a four-speed motor through a multiple V-belt. Range of horsepower is 40/30/20/15, at speeds of 1160/870/575/430 RPM. Thus, during periods of light loads, the Gas Pump may be operated at slower speeds, with less power consumption than during peak periods, effecting worth while savings.

In these times of widely fluctuating loads, it is prudent to consider utilizing equipment which offers maximum efficiency at minimum expense. It will be a pleasure to tell you more about R-C-W equipment, including Exhausters, Boosters, Meters, and Purging Machines.

Write for Bulletins 23:33-B10 and 100-B10. Estimates without charge.

ROOTS-CONNERSVILLE-WILBRAHAM

12th and Columbia

CONNERSVILLE, INDIANA

NEW YORK CHICAGO ST. LOUIS
PITTSBURGH DALLAS
POTTSTOWN, PA. SAN FRANCISCO

ROTARY POSITIVE RCW

TRADE NEWS

"Better Copy Contest" Makes Awards

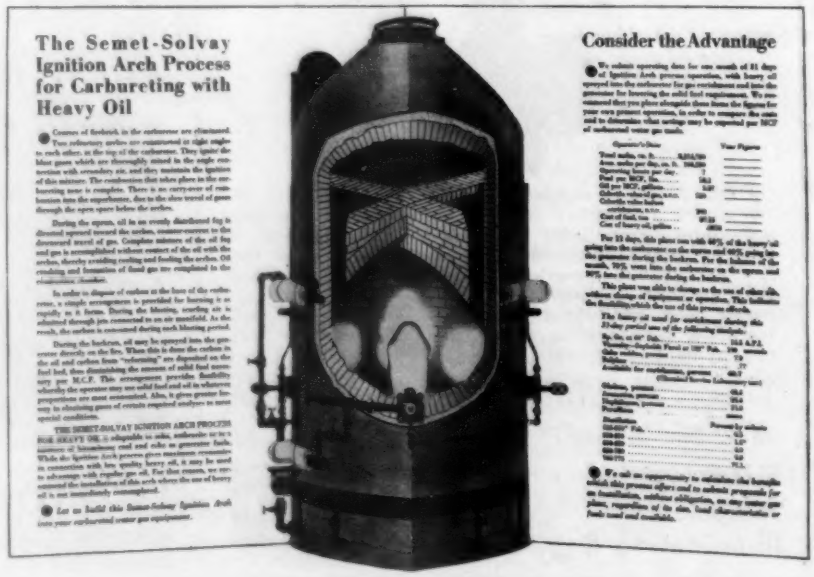
The final judging in the annual "Better Copy Contest" of the Public Utilities Advertising Association was held on April 21 in the McGraw Hill Building, when twenty-four advertisements published in 1932 were selected for awards. Announcement of the three prize-winning advertisements in the eight divisions of the Contest will be made at the annual convention of the Association, to be held in Grand Rapids in June in conjunction with the meeting of the Advertising Federation of America.

Among the judges present at the meeting were: Bruce Barton, of Batten, Barton, Durstine and Osborn; H. K. McCann, of McCann-Erickson Company; Earle Pearson, General Manager, Advertising Federation; LaBert St. Clair, American Transit Association; L. H. Boulware, Easy Washing Machine Co., Syracuse, N. Y.; and C. W. Person, American Gas Association.

F. W. Crone, Director of the Editorial Bureau, Consolidated Gas Company of New York, and Chairman of the Association's Better Copy Committee, presided.

Unique Bulletin

Semet-Solvay Engineering Corporation, 40 Rector St., New York, has recently issued an unique bulletin which explains in a striking way their Ignition Arch Process for Carbureting with Heavy Oil. This bulletin is a stiff paper folder, 8½ inches by 11 inches, which when opened causes a carburetor, in colors and to scale, to protrude from the two inside pages and thereby disclose a three-dimension illustration. This carburetor is shown with a portion of its circumference cut out which reveals the refractory arches and the brickwork inside. In short, the opening of the folder acts in the same manner as the children's story books, so much in vogue last Christmas, which, when opened, caused the illustrations to pop up from the pages. This bulletin explains the operation of the process and gives some interesting operating figures as to economies effected and the like. It is titled, Bulletin No. 46—The Semet-Solvay Ignition Arch Process Carbureting with Heavy Oil.



Republic Steel Closes Dallas Sales Office

The Dallas, Texas, District Sales Office of Republic Steel Corporation has been closed and removed to 2322 Gulf Building, Houston, Texas, N. J. Clarke, Vice-President in Charge of Sales announced recently. R. E. Lanier, District Sales Manager, and his present staff will be in charge of the new Houston office.

R. G. Hess Appointed Eastern Distributors for Stark Electroblast Furnaces

R. G. Hess, M. E., 25 Church St., New York City, were recently appointed Eastern Distributors for the Stark Electroblast furnaces, a small high temperature muffle gas furnace for laboratory and small shop work up to 2600° F.

A temperature of 2400° F. can be reached in 15 minutes from a cold furnace. The total cost of the equipment, including furnace, torch, and motor-driven blower, all portable, as illustrated, is $70.00 f.o.b. factory.

Both the Consolidated Gas Company of New York and the Brooklyn Union Gas Company are successfully selling these units.

How Gas Purifying Materials Co. spreads the story of gas. Note reproduction of gas flame

American Stove Company to Present Uses of Gas Range

The story of the gas range will be portrayed at the World's Fair in the exhibit of the American Stove Company of St. Louis and Cleveland.

This display will be incorporated in the exhibit of the American Gas Association as one of the closing chapters of its presentation of the application of gas in helping to eliminate the drudgery from housework.

G. P. M. IRON HYDROXIDE

is free of foreign matter

is impregnated on shavings—does not wash off

is uniform, active, revivifies readily

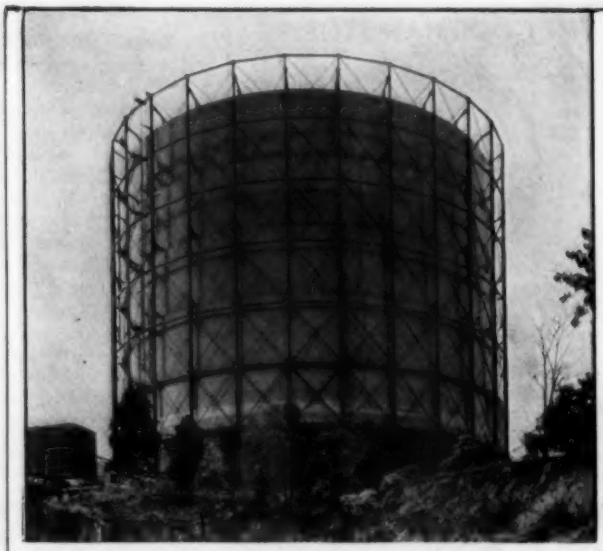
and gives the

MOST PURIFICATION FOR THE DOLLAR

Gas Purifying Materials Co. Inc.

FOOT OF HALSEY STREET — OXIDE — LONG ISLAND CITY NEW YORK

BRANCH YARD PROVIDENCE R I



HIGH PRESSURE **GAS HOLDERS** LOW PRESSURE

PURIFIERS · TANKS · CONDENSERS

STEEL PLATE CONSTRUCTION

INTEGRITY GOOD WORKMANSHIP FAIR DEALING

CRUSE-KEMPER CO.

AMBLER, PA.

Byllesby Engineering and Management Corporation

Wholly-owned subsidiary of

Standard Gas and Electric Company

231 South La Salle Street, Chicago

New York Pittsburgh San Francisco

HEATING BUNKER "C" OIL

for carburetting gas requires high pressure and high temperature.

ANDALE BOWED TUBE HEATERS

remain tight and are easily cleaned. These are the requirements for continuous satisfactory operation.

ANDALE COMPANY

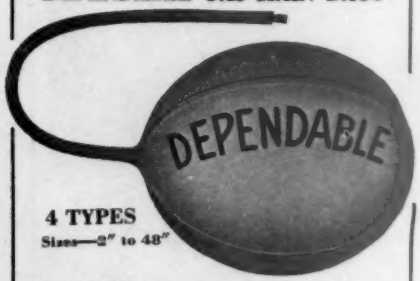
1600 ARCH STREET

PHILADELPHIA

THE GOODMAN STOPPER

The Reliable Shut-Off for Street Mains. Equipped with "Z" Handle and Locking Sleeve, which locks both handles to the pipe. Stopper cannot slip. Gas cannot pass.

DEPENDABLE GAS MAIN BAGS

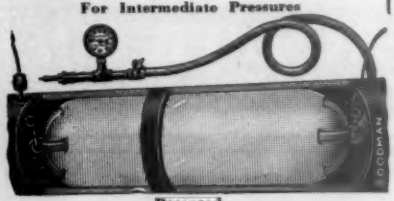


4 TYPES
Sizes—2" to 48"

Plain-Rubber—
light weight, Type "A"
medium weight, Type "B"
heavy, extra strong, Type "D"
Canvas-Covered, Type "C"

Goodman Cylindrical Stopper

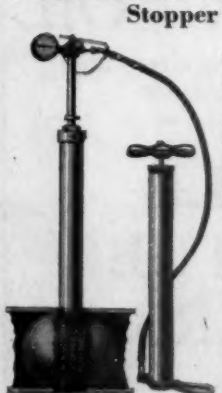
For Intermediate Pressures



Patented

This stopper is pulled into place by cables. It will hold back more pressure than any other bag. Sizes 2 in. to 48 in.

The Gardner-Goodman Stopper



Patented

Consists of an inflatable bag mounted in brass cylinder with plunger for safe and easy insertion and comes equipped with a gauge. For use on cast iron or steel, standard, oversize or undersize mains. Easily inserted in top, bottom or side of mains, in open excavation or under pavements.

For pressure work use two or more Stoppers in parallel.
Sizes 2 in. to 20 in.

Shipments From Stock

SAFETY GAS MAIN STOPPER CO.
523 Atlantic Avenue
BROOKLYN N. Y.
Pacific Coast Rep.: C. B. Babcock Co. 135 Bluxome St., San Francisco, Calif.

New Rudy Officers Named

Arthur F. Frazee was named Vice President and General Manager of the Rudy Furnace Co. by directors following the annual stockholders' meeting. Formerly Secretary and Advertising Manager, Mr. Frazee succeeds the late Charles J. Biek as General Manager.

Leo J. Biek was made Secretary and Assistant Sales Manager, and Sidney B. Tremble, former newspapermen, Treasurer and Advertising Manager.

Stockholders elected Messrs. Biek and Tremble Directors to fill board vacancies caused by the deaths of Charles Biek and Eugene Gilbert, former Treasurer. Other Directors, including Mr. Frazee and Mrs. Athur E. Rudolphi, President, were re-elected.

Taylor Forge & Pipe Works Issue New Booklet

The Taylor Forge & Pipe Works, Chicago, Ill., recently published a new booklet entitled "Designed Piping," covering flow test data and strength analysis.

A copy of this booklet may be obtained by writing direct to the manufacturer.

L. J. Mueller Furnace Co. Move Offices

The general offices of the L. J. Mueller Furnace Company, Milwaukee, Wis., maintained for 76 years at the same location at which the business was founded in 1857, were recently moved to newly built offices at the company's plant, at 2005 W. Oklahoma Ave., Milwaukee.

The removal of offices to the plant is being made in the interest of even more effective coordination between production and administrative departments, and in anticipation of an era of better business especially in the field of residence air conditioning.

Seattle Gas Company to Make New Installation

The Seattle Gas Company has contracted with the Semet-Solvay Engineering Corporation, of New York, for the installation of the Semet-Solvay ignition arch process for carbureting heavy oil and for backruns in three of its nine-foot water gas machines.

The work will involve a general rebuilding of the machines and some of the auxiliary equipment for handling gas.

The decision to install the ignition arch process came after the completion of thorough tests of the process using the low grade heavy oils available on the west coast.

Two machines will be equipped with new superheater stack valves and new wash boxes. The three machines will have Semet-Solvay 24" three-way backrun valves. Other auxiliary construction includes blast piping, and piping for water, steam, exhaust, hydraulic lines and draining.

A condenser will be retubed with Toncan tubes and changes and improvements will be made in the blower.

Work is to be started at once and is scheduled for completion this summer.

Gas and Electric Heater Company Makes New Appointments

The Gas and Electric Heater Co., LaPorte, Indiana, manufacturers of Fauce-Hot Self-Operating Gas Water Heaters and Converto Conversion Burners announce the following appointments: Herbert H. Skinner, Manufacturers' Agent, 250 Stuart St., Boston, Mass., as distributor of Gas and Electric Heater Co. products in the New England territory; Norman J. Griffiths, 600 Ogden Ave., Newark, N. J., as distributor of Gas and Electric Heater Co. products in the Metropolitan area of New York.

W. V. Daugherty Named President of The Thomas Devlin Manufacturing Co.

Mr. W. V. Daugherty has been named President of the Thomas Devlin Manufacturing Company, Burlington, N. J., manufacturers of Pipe Fittings, Nipples, Meter Fittings and Castings.

Mr. Daugherty brings with him many years of experience in both the manufacturing and selling fields. He was 10 years with the Nash Motor Company, Kenosha, Wisconsin, where he was associated with Mr. C. W. Nash, to whom Mr. Daugherty attributed much of his earlier training in sound manufacturing and merchandising practice. With the Nash Company, Mr. Daugherty was in charge of Plant Production.

Deviation of Natural Gas from Boyle's Law

(Continued from page 24)

or

$$V = Q\left(\frac{P_2d_2 - P_td_t}{P_1d_1 - P_2d_2}\right) \qquad (19)$$

The deviation, therefore, affects in two ways the calculation of the amount of reserve gas by the pressure-volume method, as it affects the actual volume of the void space in the sand body as well as the remaining pressure of the gas in the reservoir. If the correction factor is applied to the actual void space in the sand, as in equation (16) its volume is *less* than when deviation is not considered, and this part of the calculation is of such magnitude that the computed volume of reserve gas is *less*, regardless of the fact that the gas remaining in the reservoir also deviates from Boyle's law.

Cast iron is the one ferrous metal for gas mains that will not disintegrate from rust.

For further information, write to The Cast Iron Pipe Research Association, Thomas F. Wolfe, Research Engineer, 309 Peoples Gas Building, Chicago, Illinois.

An-Up-to-date-Handbook

"Elements of Gas Technology" now appearing monthly in the American Gas Journal, will constitute an up-to-date and complete handbook on manufactured and natural gas.

The alert gas man will keep a personal file of this valuable information for ready reference.

Send your order today for your own copy of the American Gas Journal. Reprints of the first three installments sent on request.

. . . . . .

Enter my order for subscription to the American Gas Journal starting with the June issue. I will remit $2.00 upon receipt of your invoice. Send reprints ☐

Name . . . . . .

Position . . . . . .

Address . . . . . .

. . . . . .

MODERNIZE WITH MOHAWK PRODUCTS

ALL STEEL TOOL AND SUPPLY TRAILERS FOR GAS AND ELECTRIC COMPANIES

MOHAWK HI-SPEED TRAILER

Hotstuf

HOTSTUF BITUMEN HEATERS. LEAD AND COMPOUND MELTING POTS.

MOHAWK ASPHALT HEATER CO. 86 WEAVER ST. SCHENECTADY, NEW YORK. 100 PARK PLACE, NEW YORK, NEW YORK.

LAVINO OXIDE

Intensely Active. High Total Sulphur Absorption at Minimum Cost.

"THE EFFICIENT PURIFIER"

The Sponge with the large Tough Shavings Always Uniform

LAVINO SPONGE

E. J. LAVINO and COMPANY - BULLITT BLDG. - PHILADELPHIA, PA.

NEW YORK CHICAGO PITTSBURGH

IMPROVED EQUIPMENT ~ RUSSELL ENGINEERING

Coal Gas Plants — Horizontal Ovens, Benches, Refills, Additions, Repairs, Charging and Discharging Machines

RUSSELL CORPORATION

24 STATE STREET
NEW YORK

Oil Gas Plants — "Refractory Screen" Process for Base — Standby or Peak Loads — On Existing or New Water Gas Sets Low or High B. T. U. Gas

PURIFYING MATERIAL — BAGGED, OR IN BULK

Manufacturers of GOVERNORS, APPARATUS *and* EQUIPMENT

IRON SPONGE

Connelly Iron Sponge and Governor Co.
Elizabeth, N.J.
Chicago

1876 [USE THE BENEFIT of 57 YEARS EXPERIENCE] 1933

Convention of Natural Gas Dept. To Be Held in Chicago in September

The Annual Convention of the Natural Gas Department of the American Gas Association will be held in Chicago the week of September 25.

The Department determined not to hold a Spring Convention in 1933, but to enlarge and expand upon its meeting as a part of the International Gas Conference and the Fifteenth Annual Convention of the American Gas Association

Doing Big Gas Business

It is understood that California has one and one-half million customers for natural gas and is selling all the natural gas it can produce, the sales made right within the state.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, of American Gas Journal, published monthly at East Stroudsburg, Pa., for April, 1933.

State of New York }
County of New York } ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared S. G. Krake, who, having been duly sworn according to law, deposes and says that he is the Manager of the American Gas Journal and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation) etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, American Gas Journal, Inc., 53 Park Place, New York City; Editor, H. M. Riley, 53 Park Place, New York City; Managing Editor, none; Business Manager, S. G. Krake, 53 Park Place, New York City.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) S. G. Krake, 53 Park Place, New York City.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is —— .(This information is required from daily publications only.)

S. G. KRAKE,
Business Manager.

Sworn to and subscribed before me this 24th day of March, 1933.

(Seal) ROZELLA BENNETT.
(My commission expires March 30, 1933.)

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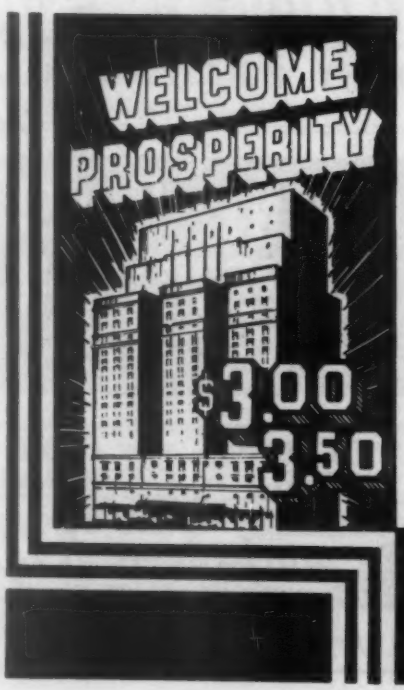
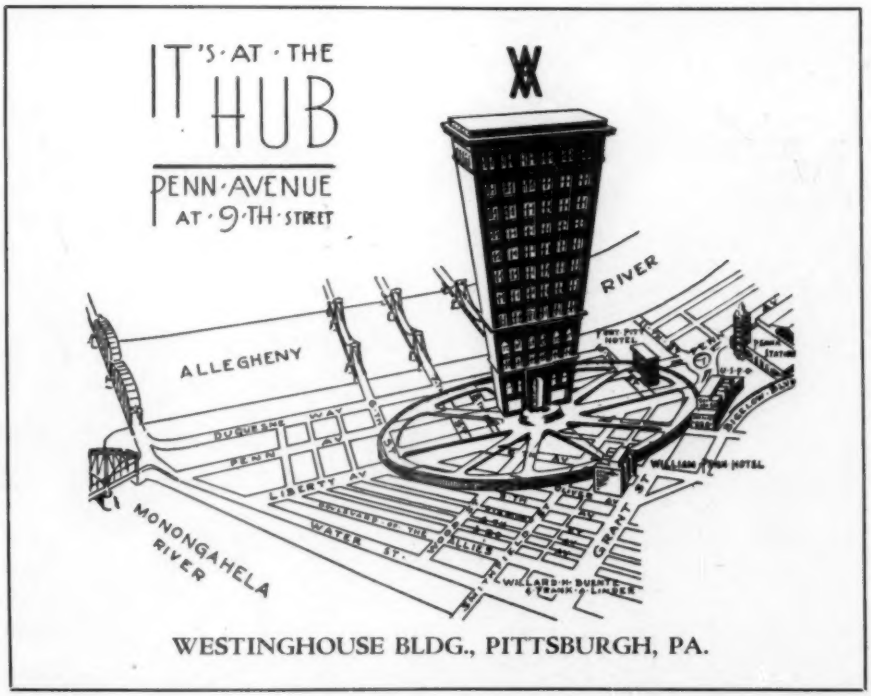


To get the traveling man back on the road and help speed prosperity, we have reduced room rates. Nearly half of the 1600 rooms... all with bath... are now $3 and $3.50.

Management EPPLEY HOTELS CO.

HOTEL
WILLIAM PENN
PITTSBURGH
Also the FORT PITT HOTEL—good rooms from $1.50; with bath $2.00

When GEO. WESTINGHOUSE built this wonderful building—the KOMPAK TYPE M HEATER had not been invented



WESTINGHOUSE BLDG., PITTSBURGH, PA.

However, the recent installation of a No. 5 M heavy duty KOMPAK saved the gas water heating load from coal stoker by reducing the gas bill by 50%. Incidentally, the room temperature of the heater room was reduced over 30°.

With a circulating system, the cost is slightly under 1 cu. ft. of natural gas per gallon of water used, with incoming cold water 50°.

This is only one of hundreds of installations made or now being made, not only serving the present load but adding millions of feet of gas yearly by replacement of coal or oil equipment.

Cheaper, inefficient heaters cannot secure this load for you. Whether for artificial or natural gas, The KOMPAK type M is a revelation in water heaters.

The Kompak Company - - - - New Brunswick, N. J.

Magic Chef ✻

NATIONAL ADVERTISING *is* DOUBLE-EDGED . . . .

MAGIC CHEF national advertising is a keen-bladed sword which has been tempered and tested by 14 years of persistent effort in educating women to more advanced methods of cooking.

In its advertising over this period, American Stove Company has always kept foremost the twofold purpose of stimulating the sale of better gas ranges and promoting the larger use of gas as a cooking fuel.

This Spring the double-edged effectiveness of American Stove Company's national advertising is even greater than it ever was before. More than 33 million advertisments dramatically present the story of special Magic Chef features in such a way that American housewives will be responsive and ready for effective demonstration.

The other keen edge of this advertising, the promotion of gas as the ideal fuel for cooking, represents substantial co-operation in protection of the cooking load, as our contribution to an urgent need of the gas industry.

The Magic Chef
GAS RANGE BURNER
that gives a thousand
even · efficient · economical HEATS a
Magic Chef
THE GAS RANGE OF TODAY
One of the series of full page Magic Chef advertisements appearing in leading national magazines this Spring

AMERICAN STOVE COMPANY

World's Largest Manufacturer of Gas Ranges

NEW YORK • PHILADELPHIA • ATLANTA • CLEVELAND
CHICAGO • ST. LOUIS • SAN FRANCISCO • LOS ANGELES

Look for the
RED WHEEL
When you buy a
MAGIC CHEF

Magic Chef

AMERICAN STOVE COMPANY

(Look for this Trade Mark)